

# LLOYDIA

*A Quarterly Journal of Biological Science*

THEODOR JUST, *Editor*

JOHN H. HOSKINS, *Associate Editor*

Vol. 2, Nos. 1-4, 1939

**LLOYD LIBRARY AND MUSEUM**

**Lloydia—Publication Office, 450 Ahnaip St., Menasha, Wis.**

**Editorial Office—309 W. Court St., Cincinnati, Ohio**

## CONTENTS

### *No. 1, March, 1939*

- Studies in North American Species of Hygrophorus—I—*Alexander H. Smith and L. R. Hesler*..... 1
- The Evolution of Habit in *Tempskya*—*Charles B. Read*..... 63

### *No. 2, June, 1939*

- Studies of Mexican and Central American Plants—VII—*C. L. Lundell*... 73
- The Cruciferous Genus *Stanleya*—*Reed C. Rollins*..... 109
- Notes on Plankton Flagellates from the Scioto River (with Descriptions of New Forms)—*James B. Lackey*..... 128
- Descriptions of New North American Species and Subspecies of *Myrmica* Latreille (Hym.: Formicidae)—*Neal A. Weber*..... 144
- The Life History of a Fungus-growing Ant of the Mississippi Gulf Coast—*A. C. Cole, Jr.*..... 153

### *No. 3, September, 1939*

- Notes on a Collection of Plants from British Guiana—*A. C. Smith (and Collaborators)*..... 161
- Caribbean Studies—I. Two New *Lincieras* and a Review of the Antillean Species—*W. H. Camp and J. Monachino*..... 219

### *No. 4, December, 1939*

- The Genus *Lecidea* in the Adirondack Mountains of New York—*Josiah L. Lowe*..... 225

### *Dates of Publication*

#### *Volume 2, 1939*

- Number 1, March.....June 30
- Number 2, June.....July 20
- Number 3, September.....Oct. 14
- Number 4, December.....Dec. 30

# LLOYDIA

## *A Quarterly Journal of Biological Science*

Published by the Lloyd Library and Museum, Cincinnati, Ohio

### Studies in North American Species of *Hygrophorus*—I\*

#### The Subgenus *Limacium*

ALEXANDER H. SMITH AND L. R. HESLER

(*University of Michigan, Ann Arbor, Mich., and University of Tennessee,  
Knoxville, Tenn.*)

#### INTRODUCTION

The species of *Hygrophorus* are characterized by their waxy appearance and consistency as well as by their white spore deposit, and thus differ from other genera of the Agaricaceae. The waxy appearance or consistency, however, is a character many people do not readily recognize with the result that they find it difficult to place their collections in the proper genus. Microscopically the long narrow basidia (30–60 $\mu$  long depending on the species) are a good indication that one is dealing with an *Hygrophorus* rather than a species belonging to some other genus of white-spored agarics. Macroscopically their generally clean appearance is distinctive.

The genus *Hygrophorus* has been variously divided into three subgenera or into two or three genera. These divisions are all based on the character of the gill-trama. No other single character has been found which enables a more useful separation to be made. Singer (18) recognized a family, the *Hygrophoraceae*, and gave *Limacium*, *Camarophyllus*, *Hygrocybe* and *Bertrandia* as genera. In north temperate regions *Limacium*, *Camarophyllus* and *Hygrocybe* are the three divisions usually recognized, sometimes as genera and sometimes as subgenera.

In our treatment of the group we are using the genus in the sense of Fries who established it as distinct from *Agaricus*. Under it we recognize the subgenus *Limacium* in which are grouped all species with divergent gill-trama, *Camarophyllus* in which all species with a distinctly interwoven gill-trama are placed, and *Hygrocybe* which includes all with parallel or sub-parallel hyphae in the gill-trama. This arrangement may be criticized as ultraconservative, but, in our estimation, it will make the work much

\* Papers from the Herbarium of the University of Michigan and Contributions from the Botanical Laboratory, The University of Tennessee, N. Ser. 32.



less confusing to those who use it, and, since the limits of the subgenera are exactly those which would otherwise be recognized as genera, nothing is lost from a strictly scientific point of view. It should also be pointed out that the subgenus *Limacium* was the first subgenus recognized by Fries in his new genus *Hygrophorus*. According to the international rules of nomenclature the name *Hygrophorus* would have to be applied to one of the segregates if the genus is divided, and since *H. ligatus* of the subgenus *Limacium*, is the first species described, it would be the type species for the genus, and the name *Hygrophorus* would necessarily have to be retained for it.

The characters by which the subgenus *Limacium* is recognized and by which the various species are separated merit discussion. By divergent gill-trama we refer to that type which is characterized by a narrow or broad central strand (in a cross section of a gill) of more or less parallel hyphae projecting from the base of the gill toward the edge. From this central strand (or plate in a face view of the gill) there are hyphae which project over to the subhymenium. Instead of projecting straight across from the central strand to the subhymenium, they project downward (toward the gill edge) at an acute angle and curve outward. Thus in a cross section of a gill one sees the central strand and from it on either side hyphae which are divergent toward the hymenium. In the subgenus *Camarophyllus* there is no such bilateral arrangement, the hyphae of the trama being merely irregularly tangled or interwoven. In *Hygrocybe*, instead of being interwoven, the hyphae are arranged in an almost parallel manner, extending from the base of the gill toward its edge.

Of the characters used to distinguish species in this subgenus the presence or absence of a glutinous universal veil and the color of the pileus are most important. In our treatment any species with a viscid stipe—even if the visciduity is scant and covers only the basal portion—is considered to possess a gelatinous universal veil. In determining this character it is obviously necessary to make accurate observations on young fruiting bodies. In some species the base of the stipe may be slightly viscid or sticky to the touch due to excess moisture, but in these no thin gelatinous veil connects the margin of the pileus with the stipe in young specimens.

The colors of the pilei when fresh are quite variable in certain species such as *H. hypothejus* Fr., and very constant in others, such as *H. speciosus* Pk. The colors of properly dried specimens are also very useful since most species have rather characteristic colors when dry or they undergo characteristic changes in drying. Until such time as accurate descriptive color notes based on color charts are available for the European species, it will be impossible to compare many of them accurately with those in America. We have endeavored to point out similarities between the species of both continents, but have refrained from reducing any to synonymy solely on

the basis of existing descriptions. We believe that when both floras have been accurately compared a number now recognized will be reduced to synonymy.

Spore size is an important character in *Hygrophorus* as in other white-spored agarics, but here, again, in order to make accurate comparisons between species, spores from spore deposits must be used, and the number of spores born on a basidium must be determined. Many species in the subgenus *Limacium* are characterized by an aromatic odor. *H. agathosmus* and *H. pusillus* are examples. This character has been found to be remarkably constant. In one group of species the gills readily become discolored with reddish spots or stains. In others the gills may change color, but the change is gradual and general throughout the gill.

The size and stature of the fruiting body are apt to be variable characters, and we consider them of secondary importance. The manner in which the lamellae are attached to the stipe is also a secondary character and of value in only a relatively few species. The spacing of the gills, however, is relatively constant and by counting the number which are attached to the stipe, one can express the character accurately.

In the United States Peck (15), Murrill (12) and Kauffman (4) have published fairly comprehensive accounts of the American species. Peck included sixteen species in the subgenus *Limacium* for New York, Kauffman recognized thirteen in Michigan, and Murrill eighteen for North America. In the present paper forty six species, varieties and forms are recognized. Eight new species, one new variety, and one new form are included in this total. Nineteen of the forty five are species or varieties described from Europe. In addition to those included in the body of the text, we have included in an appendix the names and original descriptions of other American species which previous authors have placed in *Limacium*. These should not be regarded as excluded species, but rather as species about which we have not been able to obtain sufficient information to allow them to be clearly recognized at present. Two tropical species are included in the appendix.

The field work upon which this paper is based has been in progress for a number of years. The senior author, with the aid of grants from the Horace H. Rackham School of Graduate Studies of the University of Michigan, spent two seasons collecting agarics in Washington, Oregon and California. In addition, collecting was carried on at intervals in Michigan from the season of 1934 up to the present. Expeditions to New York and Ontario were also made. The junior author has studied the flora of eastern Tennessee, and in particular that of the southern Appalachian Mountains, intermittently over a period of fifteen years. Certain unpublished species collected by Prof. C. H. Kauffman as well as his records of species of *Limacium* from various parts of the United States have also been included.



All color names within quotation marks are taken from R. Ridgway, *Color Standards and Color Nomenclature*, Washington, D. C., 1912. In citing collection numbers an "S" has been used to indicate those of Smith and an "H" those of Hesler. Specimens of each species have been deposited in both the Herbarium of the University of Tennessee and the Herbarium of the University of Michigan. Photographs on plates 1-21 were taken by Smith, those on plates 22-23 were taken by Hesler.

#### KEY TO SECTIONS OF SUBGENUS LIMACIUM\*

1. Stipe viscid or glutinous from the remains of a gelatinous universal veil..... Section *Eu-Hygrophorus* 2
1. Stipe dry or moist, sometimes subviscid to the touch but no gelatinous veil present (see *H. tephroleucus* also)..... Section *Clitocyboides* 5

#### KEY TO SUBSECTIONS

2. Pileus white with yellow granules at least along the margin of the pileus and near the apex of the stipe..... *H. chrysodon* (No. 8) 8
2. Not with the above combination of characters..... 3
3. Pileus white or pale yellow only on the disc, not brown, red, bright yellow or gray..... Subsec. *Albidi* 9
3. Pileus colored more or less over all..... 9
4. Pileus dominantly yellow, olive yellow (olive brown on disc) orange or bright red on the disc at maturity..... Subsec. *Lutei* 15
4. Pileus tawny, russet or dark pinkish tan..... Subsec. *Brunnei* 24
4. Pileus cinereous to fuliginous or blackish..... Subsec. *Fuliginei* 17
5. Gills becoming distinctly reddish spotted or staining reddish or becoming dark testaceous over all..... 8
5. Gills not as above (flushed pink in *H. calophyllus*)..... 6
6. Pileus white or creamy on the disc (tinged tan at times in *H. pusillus*) (see *H. fragrans* f. *pallida* also)..... Subsec. *Pallidi* 26
6. Pileus not white or whitish..... 7
7. Pileus pale pinkish tan, salmon color or pinkish buff, sometimes tawny to russet..... Subsec. *Fulvo-incarnati* 28
7. Pileus cinereous, fuliginous to blackish..... Subsec. *Atro-cinerei* 38
8. Gills distinctly reddish spotted (or staining wine red in *H. capreolarius*)..... Subsec. *Erubescetes* 32
8. Gills dark testaceous at maturity, never spotted..... *H. Kauffmanii* (No. 34)

#### KEY TO SPECIES

##### Section EU-HYGROPHORUS

##### ALBIDI

9. Pileus not pure white..... 12
9. Pileus pure white..... 10
10. Gills sinuate..... *H. eburneiformis* (No. 2)
10. Gills decurrent or bluntly adnate..... 11
11. Stipe 1.5-3.5 cm. thick, tapered slightly downward or equal, sometimes subbulbous and tapered to a point below the bulb. Pileus 5-14 cm. broad..... *H. ponderatus* (No. 3)
11. Stipe 2-8 (15) mm. thick, slender, equal or tapered to a vermiform base, cap 2-7 (10) cm. .... *H. eburneus* (No. 1)
12. Pileus white, disc often tinged yellow and becoming more or less yellowish in age or on drying..... 13
12. Pileus with the disc laved with pale tan or pinkish brown..... *H. laurae* (No. 7)

\* See appendix for species not included in key.

13. Upper portion of stipe when dried with reddish-brown glandular dots. .... *H. rubropunctus* (No. 4)  
 13. Upper portion of stipe in dried specimens not with reddish glandular dots. .... 14  
 14. Fruiting body changing to "ochraceous orange" or "ochraceous buff" (rather bright brownish yellow) in drying. .... *H. flavodiscus* (No. 6)  
 14. Fruiting body not changing color noticeably in age or in drying, more or less yellow at maturity and drying paler than No. 6. .... *H. gliocyclus* (No. 5)

## LUTEI

15. Pileus bright lemon yellow over all, not reddish. .... *H. lucorum* (No. 9)  
 15. Pileus differently colored. .... 16  
 16. Pileus scarlet to bright orange red, fading to yellowish at least on the margin. .... *H. speciosus* (No. 10)  
 16. Pileus dark olive to olive brown on the disc (at least when young), colors becoming brighter yellow in age. .... *H. hypothecus* (No. 11)

## FULIGINEI

17. Spores 6—8 (9) $\mu$  long. .... 18  
 17. Spores (8) 9—12 $\mu$  long. (8—10 in *H. tephroleucus*) .... 19  
 17. Spores (12) 14—18 (20) $\mu$  long. .... *H. megasporus* (No. 17)  
 18. Pileus more or less ashy gray, stature of *H. eburneus*. .... *H. occidentalis* (No. 12)  
 18. Pileus olive brown to nearly black on the disc, robust. .... *H. fuliginus* (No. 14)  
 19. Stipe with a fuscous fibrillose sheath beneath the gluten, often forming a submembranous to fibrillose-floccose superior annular zone .... 20  
 19. Stipe not as above. .... 21  
 20. Pileus 3—8 (10) cm. broad. .... *H. olivaceoalbus* (No. 15)  
 20. Pileus 1.5—3.5 cm. broad. .... *H. olivaceoalbus* var. *gracilis* (No. 16)  
 21. Odor strongly farinaceous when flesh is crushed. .... *H. multifolius* (No. 21)  
 21. Odor not farinaceous. .... 22  
 22. Pileus 5—10 cm. broad, spores (8) 9—11  $\times$  5—7 $\mu$ . .... *H. paludosus* (No. 13)  
 22. Pileus 1—4 (5) cm. broad. .... 23  
 23. Stipe with conspicuous punctate points over the upper portion. .... *H. pustulatus* (No. 20)  
 23. Stipe with fine fibrillose cinerascens pointed squamules over upper portion. .... *H. tephroleucus* (No. 18)  
 23. Stipe with fibrillose squamules bright yellow, cinerascens in age. .... *H. tephroleucus* var. *aureo-floccosus* (No. 19)

## BRUNNEI

24. Pileus 2—5 cm. broad. .... *H. discoideus* (No. 22)  
 24. Pileus 4—12 cm. broad. .... 25  
 25. Pileus white toward the margin, disc laved with pinkish brown. .... *H. lauræ* (No. 7)  
 25. Pileus tawny to cinnamon brown, margin whitish. .... *H. varicolor* (No. 23)  
 25. Pileus ferruginous to rufous, fading to sordid salmon color. .... *H. subsalmonius* (No. 24)

## Section CLITOCYBOIDES

## PALLIDI

26. Odor faintly aromatic. .... *H. pusillus* (No. 27)  
 26. Odor not distinctive. .... 27  
 27. Pileus 1—4 cm. broad (stature of *H. niveus*). .... *H. albidus* (No. 26)  
 27. Pileus 8—20 cm. broad. .... *H. sordidus* (No. 25)

## FULVO-INCARNATI

28. Flesh unchanging when bruised. .... 29  
 28. Flesh changing to yellow when cut or bruised. .... 31  
 29. Taste bitter, odor of raw potatoes. .... *H. tennesseensis* (No. 31)  
 29. Taste mild, odor aromatic, spores 11—14 $\mu$  long. .... *H. pacificus* (No. 33)  
 29. Odor and taste not distinctive. .... 30



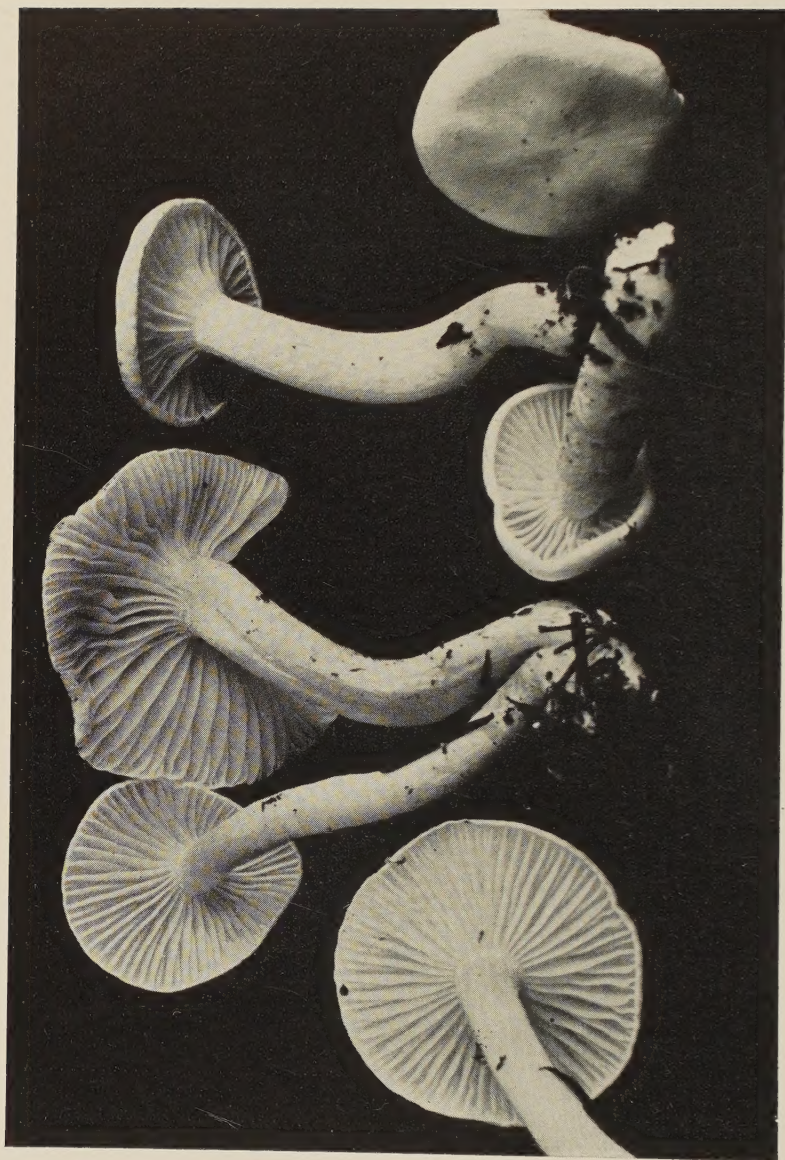


Plate 1, *Hygrophorus eburneus* Fr. xi.



30. Pileus 5—12 cm. broad.....*H. pudorinus* (No. 28)  
 30. Pileus 2—5 cm. broad.....*H. roseibrunneus* (No. 32)  
 30. Pileus 4.5—7 cm. broad, spores 6—7.5  $\times$  3.5—4  $\mu$ .....*H. subisabellinus* (No. 30-a)  
 31. Pileus more or less salmon color.....*H. fragrans* (No. 29)  
 31. Pileus pale yellowish buff.....*H. fragrans* f. *pallida* (No. 30)

## ERUBESCENTES

32. Gills crowded and long decurrent as in species of *Clitocybe*.....*H. proximus* (No. 38)  
 32. Gills not long decurrent.....33  
 33. Taste persistently bitter.....*H. amarus* (No. 39)  
 33. Taste not bitter.....34  
 34. Fibrillose veil present forming an evanescent fibrillose ring near the apex of the stipe.....*H. purpurascens* (No. 41)  
 34. Fibrillose veil not present.....35  
 35. Pileus evenly dark wine-red, lamellae concolorous with pileus.....*H. capreolarius* (No. 40)  
 35. Pileus dull rose to purplish on disc, margin paler, gills spotted reddish.....36  
 36. Pileus 2—3 cm. broad.....*H. erubescens* var. *gracilis* (No. 37)  
 36. Pileus larger.....37  
 37. Lamellae close to crowded, (120—130 reach the stipe).....*H. Russula* (No. 35)  
 37. Lamellae subdistant to close (75—95 reach the stipe).....*H. erubescens* (No. 36)

## ATRO-CINEREI

38. Odor aromatic.....*H. agathosmus* (No. 42)  
 38. Odor not noticeable or very slight.....39  
 39. Upper portion of stipe white floccose-scabrous.....*H. fusco-albus* var. *occidentalis* (No. 45)  
 39. Upper portion of stipe not floccose-scabrous.....40  
 40. Pileus soon dry, gills cinerascens.....*H. caprinus* (No. 43)  
 40. Pileus remaining viscid, gills remaining white or becoming flushed with pink.....*H. calophyllus* (No. 44)

## Section EU-HYGROPHORUS

Subsec. *Albidi*

In this subsection are grouped all the white or nearly white species with a glutinous universal veil. There is no sharp dividing line between this and the following subsection. The disc of the pileus is tinted yellow or pale brown in some, and in some the color becomes more pronounced as the fruiting bodies are dried.

## 1. HYGROPHORUS EBURNEUS Fr. Plate 1.

(*Clitocybe albicostanea* Murr. Mycologia 5:206. 1913.)

Pileus 2—7 (10) cm. broad, obtuse to convex at first, plane or umbonate when expanded, in age the margin sometimes elevated and the disc depressed, glutinous to viscid, glabrous or with a whitish shining silkiness, margin even and at first involute and floccose-pubescent, pure white over all; flesh thick under the disc, thin toward the margin, firm, white, odor and taste mild; lamellae somewhat arcuate at first, soon decurrent, subdistant to distant, moderately broad (5 mm.  $\pm$ ), broadest near the stipe, narrowed in front, pure white or slightly discolored yellowish in age or occasionally reddish in extreme age; stipe 4.5—15 (18) cm. long, 2—8

(15) mm. thick, equal to more or less tapered downward or with a greatly attenuated almost vermiform base, flexuous, very glutinous, silky beneath the gluten, apex white fibrillose punctate or minutely squamulose, pure white, becoming sordid in age at times, stuffed but becoming hollow; spores 6—8 (9.5)  $\times$  3.5—5 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

This is perhaps the commonest species of the subgenus in the United States. In Michigan it has been collected in beech woods, and in addition Kauffman (4) reported it from thickets and grassy areas. In Tennessee it grows in both conifer and hardwood forests, and in Oregon and California the same wide range of adaptability has been observed. In southern Oregon it has been found in exceptionally large quantities in mixed forests of oak and pine. Murrill (11) and Zeller (22) have both commented on the abundance of this species on the west coast, and it is reported in most of the floristic studies on agarics in this country. The numerous descriptions in the literature agree very well on the important diagnostic characters.

Ordinarily pilei which are not overmature will remain almost pure white if properly dried. Occasionally old specimens may become yellowish or sordid in drying, and if any material is overheated a change in color is almost certain to take place. The base of the stipe nearly always dries a sordid tawny brown. Kauffman (4) recognized two varieties. We have not collected *H. eburneus* var. *unicolor* (Pk.) Kauff. which is said to change color on drying. The species as we have found it is very variable in stature, and we have not found any constant forms or varieties which appear to be worthy of recognition.

2. *HYGROPHORUS EBURNEIFORMIS* Murr. *Mycologia* 30:364. 1938.

"Hymenophores dazzling white and slimy viscid on surface and stipe, gregarious; pileus convex, umbonate to expanded and irregular, reaching 6 cm. broad; surface smooth, margin undulate to lobed; context thin, white, unchanging, mild; lamellae sinuate, moderately broad and distant, interveined, entire; spores ovoid or broadly ellipsoid, smooth, hyaline, 7—9  $\times$  5 $\mu$ ; stipe subequal, smooth, glabrous, with satiny sheen, hollow, about 4  $\times$  1—2 cm."

This recently described species was collected by Murrill (13) in leafmold under a magnolia in Alachua County, Florida. Through the courtesy of Mr. Erdman West of the Florida Agricultural Experiment Station we have been able to examine a portion of the type and to study its microscopic characters. Sections of the gill-trama revived in 3% KOH do not show the typical divergent hyphae characteristic of this subgenus. The subhymenium and adjacent areas seem to be made up of narrow slightly interwoven hyphae. A study of revived material of other species of *Lima-cium* which were known to have divergent gill-trama was made as a com-



parison, and it was found that in the less robust species the gill-trama does not always revive in such a way as to give the original arrangement of its hyphae. For this reason further studies of fresh material are desirable on Murrill's species. As Murrill has pointed out, it should be readily recognized by its sinuate gills.

### 3. HYGROPHORUS PONDERATUS Britz. Plate 2.

Pileus 5—14 cm. broad, convex then plane, finally depressed, white, viscid or glutinous, glabrous, margin even and at first incurved and floccose; flesh white, compact, thick, odor and taste mild; lamellae adnate to decurrent, subdistant, rather broad, narrow at either end, often subtriangular, white; stipe 2.5—5.5 cm. long, 1.7—3.5 cm. thick, equal or tapering either way, at times subbulbous and tapering below the bulb, lubricous or viscid-glutinous when wet, silky-fibrillose, solid, partial veil arachnoid in young specimens; spores  $6.5-8 \times 4-5\mu$ , ellipsoid; basidia  $55-60 \times 8-9\mu$ , four-spored; gill-trama of divergent hyphae, cells  $8-10\mu$  dia.

This species has been found during the winter in oak-pine woods in Tennessee. Britzelmayer (3) characterized his species as having cap and stipe viscid, spores  $8-9 \times 4-5\mu$ , and "der Pilz in allen seinen Theilen aussen u. innen weiss." He compared it to *H. gliocyclus*. Nüesch (14) suggested that it was closer to *H. penarius* because of the attenuated base of its stipe along with such characters as the slightly viscid pileus and stipe. Nüesch, apparently, had never collected the species, so it seems logical to limit ourselves to Britzelmayer's description. The outstanding characters of the Tennessee collections are the white color in all parts (this color is retained in drying), the viscid pileus and stipe, spore size, and general resemblance in stature to *H. gliocyclus*. It can be readily seen that the American collections agree perfectly with Britzelmayer's description on all important characters. We are inclined to discount any apparent differences in the size and shape of the stipe as variations similar to those frequently encountered in such common species as *H. eburneus*. In North America *H. ponderatus* is most likely to be confused with *H. sordidus* Pk., another large white species with a slight arachnoid partial veil at times. The latter, however, has a truly dry stipe in all stages of its development.

### 4. HYGROPHORUS RUBROPUNCTUS Pk.

(*Hygrophorus glutinosus* Pk. Bull. N. Y. State Mus. 10:950. 1902.)

Pileus 2.5—5 cm. broad, firm, convex, glutinous, white, sometimes tinged with yellow, involute on the margin; lamellae adnate, persistently white, subdistant; stipe 2.5—4 cm. long, 6—8 mm. thick, equal, solid, white floccose tomentose below the glutinous annulus, studded above with drops of moisture which in drying form reddish glandular dots; spores  $8-10 \times 5-6\mu$ ; ellipsoid.



Plate 2, *Hygrophorus ponderatus* Britz., slightly reduced.



We have not seen fresh specimens of this species, and hence limit our comments to observations of the type. The species is very closely related to *H. eburneus*, *H. flavodiscus* and *H. gliocyclus*. The varnished appearance of the pileus and the lower half of the stipe verify the glutinous character of the universal veil. The pileus has dried "Pale Orange-Yellow." This is a distinctly paler color than the "Ochraceous-Orange" of dried fruit-bodies of *H. flavodiscus*. It is more yellowish than is typical for old specimens of *H. eburneus*, but is almost identical with the colors of dried specimens of *H. gliocyclus*. Under a lens the reddish punctate spots on the apex of the stipe appear to arise from a fibrillose covering which is distinctly visible in the dried specimens, and it is apparent that fibrillose scabrous points arose from this layer. The reddish spots for the most part coincide with these scabrous points and it is thus quite apparent that in this species the upper portion of the stipe is scabrous punctate when fresh and that it dries in a similar manner to that of *H. pudorinus*. *H. gliocyclus* does not have reddish punctate spots on the upper part of the stipe in dried specimens. *H. flavodiscus* shows a slight tendency to develop such reddish brown spots, but the character is not pronounced in the specimens we have studied.

#### 5. HYGROPHORUS GLIOCYCLUS Fr.

Pileus 4—8 cm. broad, convex, obtuse or expanded, subumbonate, whitish to cream-yellow or straw yellow, glutinous, with a separable pellicle when dry, glabrous, even, margin at first involute; flesh compact and thick on the disc, abruptly thin on the margin, white, unchanging, odor and taste mild, lamellae decurrent, subdistant, narrow, creamy yellowish ("Ivory Yellow") to more dingy yellowish in age; stipe 3—8 cm. long, 15—25 mm. thick, equal to slightly ventricose, abruptly attenuated at the base, solid, whitish, sheathed by a hyaline glutinous veil which terminates in a narrow sometimes obsolete glutinous annulus, apical region at first white floccose but becoming silky fibrillose; spores 7—9 ( $11$ )  $\times$  5—6 $\mu$ , oblong-ellipsoid, obliquely apiculate, hyaline, smooth; basidia four-spored; gill-trama of divergent hyphae.

Gregarious or subcespitose under spruce and pine, Wyoming and Colorado. We have not collected it, and include it because of Kauffman's collections in the Rocky Mountains. Kauffman's notes clearly describe it in accordance with the characters given by European investigators. Apparently both a robust and a slender form exist in this species as well as in others of this subgenus. A specimen from Dr. Rolf Singer, Leningrad, U.S.S.R., represents a small slender form whereas Kauffman's material represents the robust form usually described as typical. *H. flavodiscus* Pk. is closely related but should be readily distinguished by the color changes which take place when specimens are dried. In the absence of more accu-

rate information on the characters of the partial veil of *H. flavodiscus*, the latter cannot be compared to *H. gliocyclus* in this respect.

#### 6. *HYGROPHORUS FLAVODISCUS* Fröst in Peck.

Pileus 2.5—7.5 cm. broad, convex or plane, smooth, glutinous, white, with a pale yellow or reddish yellow disc, flesh white; lamellae adnate or decurrent, subdistant, white, sometimes with a slight flesh colored tint, the interspaces sometimes veiny; stipe subequal, glutinous, white, sometimes slightly stained with yellow; spores ellipsoid,  $7-9 \times 4-5\mu$ .

We have not collected this species and base our comments on our studies of Peck's specimens. The latter have dried to an "Ochraceous-Orange" or "Ochraceous-Buff" color, and are obviously much brighter in color when dry than when fresh. This color change in addition to the statements in the original description that the fruiting bodies were white but became tinged with yellow, leads us to believe that this is a species which changes color as the fruiting bodies become old or are dried. It can be readily determined from Peck's specimens that the apex of the stipe was scabrous-punctate in the fresh condition. In searching the European literature for such a species one is immediately impressed with the characters of *H. melizeus* Fr., which by some authors is considered a variety of *H. eburneus*. Fries characterized *H. melizeus* as similar to *H. eburneus* but becoming pallid ochraceous throughout. From this it is logical to assume that it possesses the same type of glutinous universal veil as *H. eburneus* and that Ricken's (17) description applies to another species. Further studies of *H. flavodiscus* should be made with its relationship to *H. melizeus* in mind.

#### 7. *HYGROPHORUS LAURAE* Morg.

Pileus (2) 4—10 cm. broad, umbonate, convex-expanded or sometimes depressed on the disc, white toward the margin, the disc washed with reddish brown or pinkish tan, sometimes yellowish brown, surface viscid to glutinous, more or less silky shining beneath the gluten, margin even, undulate or sometimes crenate; flesh white, firm, rather thick (8—10 mm. on the disc), odor and taste not distinctive; lamellae broadly adnate, decurrent by a tooth, subdistant to close, white becoming slightly tinged flesh color, narrowed at either end, broadest (about 7 mm.) at the center, edges even, rarely forked; stipe short, rather stout, 2.5—3.5 (8) cm. long, (8) 10—27 mm. thick, whitish or dingy, fibrillose below, at first floccose-squamulose above, then fibrillose, tapering downward, sometimes curved at the base, solid, viscid or glutinous over the lower portion; spores ellipsoid,  $6-8 \times 3.5-4.5\mu$ ; gill-trama of divergent hyphae.

Gregarious to subcespitate on humus in hardwoods or mixed conifer and hardwood forests, Ontario, Michigan and Tennessee. Our specimens compare very favorably with Morgan's (10) illustration of the species.



The stems, however, may be quite long at times. The pilei dry "Pinkish Buff" to "Cinnamon-Buff" on the disc and whitish on the margin. The scabrous points over the apex of the stipe dry white or very pale yellow. Of the related European species, *H. leucophaeus* Scop. sensu Konrad (6) is very close, but *H. laurae* has a very glutinous stipe thus imitating *H. eburneus*. *H. laurae* is very readily distinguished from *H. flavodiscus* by the colors of the dried specimens.

#### 8. HYGROPHORUS CHRYSODON Fr. Plate 3.

Pileus 3—8 cm. broad, convex, becoming expanded, subumbonate or obtuse, viscid when moist, shining when dry, white and unicolorous except for superficial numerous golden yellow ("Apricot Yellow") floccose granules on the margin or over all at first, margin at first involute and white floccose tomentose; flesh white, rather thick, soft, odor and taste not distinctive; lamellae decurrent, distant, white or with yellow powder on the edges, intervenose, moderately broad; stipe 3—8 cm. long, 6—12 (18) mm. thick, equal, viscid, stuffed, white but decorated especially above by yellow floccules which may form an imperfect zone or ring; spores ellipsoid, smooth, white in mass,  $8-10 \times 4-5\mu$ ; basidia four-spored; gill-trama of divergent hyphae.

This is a widely distributed and easily recognized species. We have not found *H. chrysodon* var. *leucodon* Alb. & Schw. which is said to be characterized by white instead of yellow granules. The species is very abundant at least during certain seasons in California, Oregon and Washington, but is rare in Michigan. As an edible mushroom, this species, at least as it is found in the conifer forests of our western states, is not to be recommended because of the rather strong, disagreeable flavor of the cooked pilei.

#### Subsec. *Lutei*

The species in this subsection are characterized by a glutinous universal veil which leaves a peronate slimy sheath on the stipe, and by the yellow or orange, red or dark olive yellow pilei. For species with yellowish discs see subsection *albidi*. There is no sharp division line between these two groups.

#### 9. HYGROPHORUS LEUCORUM Kalchbr.

Pileus 2—6 cm. broad, campanulate-convex, obtuse or umbonate, explanate or depressed, bright lemon yellow, fading, never fulvous or golden reddish on the disc, viscid, even or rugulose from drying gluten, glabrous, margin often floccose with remnants of the white veil; flesh white, lemon yellow under the pellicle, soft, thin on the margin, odor and taste mild; lamellae adnate-decurrent, subdistant, whitish, often lemon yellow toward the margin of the pileus, sometimes entirely lemon yellow, moderately broad; stem 3—7 cm. long, 4—12 mm. thick, whitish or pale yellow, equal



Plate 3, *Hygrophorus chrysodon* Fr. xi.



or irregularly subcompressed, stuffed and soft within, becoming flocculose from the glutinous white veil; spores  $8-11 \times 5-6\mu$ , broadly ellipsoid, smooth, hyaline, basidia four-spored; gill-trama of divergent hyphae.

Found scattered in boggy places and low woods, collected by Kauffman in Michigan. We have not seen this species, and Kauffman's specimens from which the above notes were taken have not been located. It should be readily recognizable by the bright lemon yellow color of the pileus. Nüesch (14) reports it as growing under larch whereas *H. aureus*, a species apparently intermediate between this and *H. speciosus*, is reported as growing under other conifers.

#### 10. HYGROPHORUS SPECIOSUS Pk. Plate 4.

(*Hygrophorus coloratus* Pk. N. Y. State Mus. Bull. 122:21. 1908.)

Pileus 2-8 cm. broad, campanulate at first, then expanded umbonate or umbo obsolete in age, glutinous, glabrous, margin at first merely incurved, soon spreading, entirely bright scarlet red or rosy reddish orange when young, fading near the margin to yellow but remaining orange-red on the umbo; flesh white, yellow or orange tinted under the separable pellicle, moderately thick and soft, odor and taste not distinctive; lamellae decurrent, distant, rather broad, acute at the ends, thick, intervenose, white to pale citrine; stipe 3-10 cm. long, 8-15 (20) mm. thick, equal or irregularly subcompressed, coated over the lower half with gelatinous universal veil remnants and spongy within, rarely hollow, peronate from a thin white-fibrillose partial veil up to the evanescent annular zone, becoming white floccose-fibrillose, upper portion subglabrous; spores  $8-10 \times 5-6\mu$ , broadly ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

We have found it growing scattered to gregarious, usually under larch in bogs in Michigan, New York and Tennessee. In Europe there is a rather closely related series of species distinguished largely on color differences. In our studies we have been able to recognize only the species with a bright red pileus when young, and have used the name given to American specimens by Peck.

#### 11. HYGROPHORUS HYPOTHEJUS Fr. Plate 5.

(*Hydrocybe arenicola* Murrill, Mycologia 4:208. 1912. *Hygrophorus subpustulatus* Murrill, Mycologia 4:210. 1912.)

Pileus 2-8 cm. broad, with a slight obtuse umbo at first, becoming convex to plane or remaining slightly umbonate, sometimes with a depressed disc and an elevated margin at maturity, surface covered by a thick layer of hyaline gluten at first, glabrous or somewhat agglutinated fibrillose near the margin, colors "Bone Brown" to "Olive-Brown" on the disc and "Pale Dull Green Yellow" toward the margin, colors becoming brighter in age ("Straw Yellow" to "Ochraceous-Orange" or occasionally



Plate 4, *Hygrophorus speciosus* Pk. XI.



"Scarlet" in extreme age near the margin), disc remaining more or less dark olive brown; flesh thin, yellow near the pellicle, watery whitish above the lamellae, odor and taste not distinctive; lamellae white at very first, soon pale yellow and finally more or less concolorous with the margin of



Plate 5, *Hygrophorus hypothejus* Fr. x1, slender form.

the pileus, narrow to moderately broad, decurrent, subdistant to distant; stipe (2.5) 8—16 cm. long, (3) 6—12 (15) mm. thick, tapering slightly downward, solid, flesh whitish or yellowish near the exterior, the lower two-thirds covered by a thick glutinous sheath from the universal veil, partial veil floccose and leaving a subapical fibrillose evanescent annular zone, apical region silky and yellowish, variously colored below—olive

brown, olivaceous yellow, bright yellow, orange or scarlet; spores 7—8.5 (10)  $\times$  (3.5) 4—5.5 $\mu$ , ellipsoid, hyaline, smooth; basidia four-spored; gill-trama of divergent hyphae.

Gregarious under pine, Tennessee, Oregon and Michigan. Murrill (12) reports it as occurring throughout temperate North America. In Oregon both the form illustrated in Plate 4 and the one shown by Bresadola (2), Plate 317, were collected. The species is quite variable but at the same time readily recognizable. The tendency of the fruiting bodies to become rather brightly colored has led us to place it in this subsection along with other bright yellow or reddish species. We have not collected *H. elegantulus* Pk., *H. amygdalinus* Pk., *H. Morrisii* Pk., or *H. arenicola* Murr., all of which have been referred by Murrill (12) to *H. hypothejus* as synonyms. *H. fuliginus* is a distinct species and has generally been recognized as such by American investigators.

#### Subsec. *Fuliginei*

This is a comparatively large group of species characterized by the gelatinous universal veil the remnants of which cause the stipe to be viscid, and the pilei gray, olive gray, fuscous or blackish. *H. multifolius* Kauff. is included here, but is characterized by its *Clitocybe*-like appearance, farinaceous odor and short basidia. It needs further study.

#### 12. *Hygrophorus occidentalis* sp. nov. Plate 6.

Pileus 3—8 (10) cm. latus, convexus demum planus vel late depressus, glutinosus, virgatulus, fuscus, margine albidus vel cinereus; caro albida, inodora, sapore miti; lamellae albae, confertae vel subdistantes, decurrentes, angustae; stipes 4—7 cm. longus, 5—9 (15) mm. crassus deorsum attenuatus, solidus, glutinosus, apice siccus et minute albidopunctatus, sordide albidus; sporae 6—8  $\times$  4—5 $\mu$ ; basidia tetraspora. Specimen typicum legit prope Ann Arbor, Mich., Oct. 8, 1936, A. H. Smith n. 5088, in Herb. Michigan conservatum.

Pileus 3—8 (10) cm. broad, convex at first, soon expanded plane, at maturity the disc slightly depressed and the margin decurved, in age the disc deeply and broadly depressed and the margin elevated, glutinous at first from the remains of a hyaline gelatinous universal veil, somewhat appressed fibrillose streaked beneath the gluten, color variable, disc "Hair Brown" to "Fuscous" and paler toward the white to pale cinereous margin; flesh thin, white, odor and taste not distinctive; lamellae white, close to subdistant, adnate, becoming subdecurrent or decurrent, narrow to moderately broad (5 mm.  $\pm$ ), thin, edges even; stipe 4—7 cm. long, 5—9 (15) mm. thick, equal above a gradually tapered base, solid and white within, lower portion glutinous from the universal veil remnants, with appressed white fibrils beneath the gluten, apex minutely white



Plate 6, *Hygrophorus occidentalis* Smith & Hesler, slightly reduced.



punctate or pruinose-punctate, pallid or concolorous with the pileus; spores  $6-8 \times 4-5\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

This species can be briefly characterized as a gray to fuscous *H. eburneus*. In Oregon both were collected in the same oak-pine woods and were scarcely distinguishable when young. The fuscous color is usually present at least on the disc at maturity, however, and soon spreads throughout the fruiting body as the specimens begin to dry. In Michigan and Tennessee it has been found in oak-pine woods and in stands of oak and hickory. When dried the specimens are often tinged with tawny brown and small ones somewhat resemble specimens of *H. discoideus*. The small spores should separate it readily from *H. limacinus*, *H. lividoalbus* and *H. fuscoalbus*. It is possible that reports of *H. limacinus* for North America are based on this species. Nüesch's (14) description of *L. mesolephrum* fits our species in most important characters, but again the spore size is not the same ( $10-12 \times 5-8\mu$ ). Rea (16) gives the spores of the latter as  $9 \times 6\mu$ , and emphasizes yellowish stains on the stipe in addition to the small size ( $2-3$  cm. broad). All of these are characters which our specimens did not possess.

### 13. *HYGROPHORUS PALUDOSUS* Peck. Plate 7.

Pileus 5—10 cm. broad, convex or obtusely conic at first, plane or broadly depressed in age, surface covered by a thick (2—3 mm.) layer of gluten which becomes more or less washed off by maturity, gluten hyaline at first but becoming smoky tinged in age, surface paler or dark fuliginous with an ochraceous sheen when young, in age appearing netted beneath the gluten and tinged pinkish-vinaceous or purplish umber; flesh thick, white, soft, not changing color when cut or bruised, odor and taste not distinctive; lamellae white, often becoming sordid greenish spotted in age, adnate, becoming decurrent, moderately broad, close to subdistant; stipe 6—12 cm. long, 1—2 cm. thick, equal above a narrowed base, subradicating, solid, covered by a thick glutinous sheath over the lower two-thirds and a thin white fibrillose sheath present beneath the gluten, white and scabrous-punctate above, in age the scales or points staining sordid yellowish to greenish, gluten pale smoky to nearly hyaline at first and leaving sordid bands over the lower portion when dry, white beneath the gluten, sometimes sordid greenish at the base in age; spores  $9-11 \times 5-7\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Scattered to gregarious in open oak-hickory woods in Tennessee and Michigan.

We have been unable to locate the type of this species, but typical material has been collected and redescribed from Michigan, see Smith

(19). Continued collecting in the woods from which the first specimens were obtained has brought out certain interesting facts in regard to this species. The greenish spots on the gills and sordid yellowish green stains



Plate 7, *Hygrophorus paludosus* Pk. x1.

on the upper part of the stipe do not always develop—particularly in dry or moderately dry weather. As a result of this observation, and many collections of a species from the west coast which seemed to be *H. olivaceoalbus* Fr., we were led to study Kauffman's specimens of the latter species. All of his specimens of *H. olivaceoalbus* are similar and do not show any



signs of the fuscous fibrillose sheath which is the distinguishing character of that species. Upon comparing specimens of *H. paludosus* with those Kauffman named *H. olivaceoalbus*, it was at once apparent that they were the same. Hence we believe that Kauffman's (4) description of *H. olivaceoalbus* actually applies to forms of *H. paludosus* which did not develop the characteristic stains. In searching the literature for a European species which is closely related to Peck's, one is at once impressed with the similarity of *H. fuscoalbus* sensu Ricken. The latter is said to grow in coniferous woods, however, and, except for spore size, might be regarded as closer to *H. fuliginus*.

#### 14. HYGROPHORUS FULIGINEUS Frost in Peck.

Pileus 4—10 (12) cm. broad, fleshy, convex then obtuse or expanded plane, thick, covered with a thick layer of hyaline gluten beneath which the surface is at first blackish or "Clove Brown" to "Brownish Olive," slightly paler toward the margin, becoming grayish brown or olive-gray and subvirgate after the gluten dries, glabrous, even, margin at first involute, thin, spreading; flesh thick, white, slightly tinted under the separable colored cuticle, odor and taste not distinctive; lamellae adnate or subdecurrent, attenuated at either end, narrow to moderately broad, close to subdistant, rather thin, whitish to creamy white ("Ivory Yellow"), rarely forked; stipe 4—10 (12) cm. long, 10—20 mm. thick, equal or tapering below, sometimes incrassate at the base, covered by the hyaline glutinous veil, annulus obsolete, whitish, sometimes fuscous dotted after drying, slightly silky or naked above, white, solid and white within; spores ellipsoid, hyaline, smooth,  $7-8 (9) \times 5-6\mu$ ; basidia four-spored; gill-trama of divergent hyphae.

Scattered to gregarious under pine and hemlock in Michigan and under rhododendron, pine and hemlock in Tennessee. It is apparently a rather widely distributed species in eastern United States.

Bresadola (2) considered it to be synonymous with *H. limacinus* but his illustration of the latter certainly does not represent the American species. His description, however, might apply to either *H. fuliginus* or *H. paludosus*. We have not noted a tendency of the gills to become grayish in *H. fuliginus*, and since *H. limacinus* is usually described as having spores  $10\mu$  or more long, we do not believe that *H. fuliginus* should be reduced to synonymy with it. Bresadola (2) mentions having studied dried specimens of the American species, and states that its spores measure  $8-10 \times 5-6\mu$ . The possibility that he actually examined a specimen of *H. paludosus* in which the greenish and yellowish stains did not develop is by no means excluded since the two are very similar in many respects. In spore deposits, however, the spores of *H. paludosus* are consistently larger than those of *H. fuliginus*, the apex of the stipe of the latter is not

scabrous, and there are differences in color in addition which are sufficient to establish both as distinct.

15. *HYGROPHORUS OLIVACEOALBUS* Fr. Plate 8.

Pileus 3—8 (10) cm. broad, convex or with a somewhat pronounced umbo, often nearly flat when expanded, glutinous to viscid, conspicuously virgate beneath the gelatinous layer with smoke gray to blackish fibrils, disc umber to black, the margin paler and dark to light ash-gray; flesh thick on the disc, soft, white, odor and taste not distinctive; lamellae pure white or somewhat ashy at the base, moderately broad, adnate to subdecurrent, thickish, close to subdistant; stipe 8—12 (15) cm. long, 1—3 cm. thick, clavate to equal, solid, white within, peronate to near the apex with a double sheath, the outer layer glutinous, the inner layer of appressed blackish fibrils similar to those on the pileus and forming a subfloccose evanescent apical annular zone or submembranous annulus, in age the sheath often breaks up into dark concentric ragged bands over the lower portion, white and glabrous to pruinose above the annulus; spores 9—12  $\times$  5—6 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Cespitose, gregarious or scattered under redwood and spruce, California and Colorado.

The outstanding character of this species is the double sheath over the greater portion of the stipe. The outer layer is glutinous and the thin inner layer is composed of floccose fibrils similar in color with and at first connected to the fibrillose coating under the gluten of the pileus. As the stipe elongates the inner sheath breaks up into irregular fuscous bands. The American specimens have been compared with specimens from Dr. Rolf Singer, Leningrad, U.S.S.R., and Mr. Marcel Jossierand, Lyon, France. Kauffman's (5) collections of *H. fuscoalbus* from Colorado belong in *H. olivaceoalbus*. For comments on the species Kauffman referred to *H. olivaceoalbus* see *H. paludosus*.

16. *HYGROPHORUS OLIVACEOALBUS* var. *GRACILIS* Maire.

Pileus 1.5—3 cm. broad, conic, campanulate or plane, glutinous, virgate with dark cinereous fibrils beneath the gluten, disc blackish, margin sordid olivaceous-cinereous; flesh whitish or tinged cinereous, odor and taste not distinctive; lamellae white, broad, distant, decurrent, edges even; stipe 6—8 cm. long, 5—7 mm. thick, surface covered by a thin glutinous sheath over the lower portion, smoky olive beneath the gluten and appressed fibrillose with smoky olive fibrils, apical annular zone white above and ashy-gray beneath, white and silky at the apex; spores 10—14  $\times$  6—7.5 $\mu$ , ellipsoid, smooth; basidia two-, three-, and four-spored; gill-trama of divergent hyphae.



Plate 8, *Hygrophorus olivaceolubus* Fr. xi.



Scattered under fir, Oregon. This is an apparently constant slender form in which, at least in our material, the number of spores born on a basidium varies greatly in a single pileus. This condition is correlated with an increase in spore size. The variety is similar in all other respects to typical material.

17. *Hygrophorus megasporus* sp. nov.

Pileus 2—5 cm. latus, campanulatus, mammillate umbonatus, glutinosus, fuligineo-olivaceus; caro albida, inodora, sapore miti; lamellae adnatae demum subdecurrentes, candidae; stipes (4) 5—10 cm. longus, 3—6 (8) mm. crassus, equaliter vel subventricosus, deorsum attenuatus, solidus, glutinosus, albidus demum fuligineo-olivaceus; sporae (12) 14—18 (20)  $\times$  7—9 $\mu$ ; basidia tetraspora. Specimen typicum legit prope Lake Quinault, Wash., C. H. Kauffman, Nov. 2, 1925, in Herb. Univ. of Michigan conservatum.

Pileus 2—5 cm. broad, fleshy, at first broadly campanulate, with a mammillate umbo, at length expanded plane, glutinous from the hyaline veil, surface beneath "Buffy Olive" with the umbo "Clove Brown," margin slightly paler, glabrous, the surface often uneven from the drying gluten, margin incurved and membranous; flesh thin, white, unchanging, odor and taste mild; lamellae adnate with a tooth, becoming subdecurrent, close to subdistant, thickish, waxy, a few forked, 3—4 mm. broad, pure white; stipe slender (4) 5—10 cm. long, 3—6 (8) mm. thick, equal or slightly ventricose and attenuated at the base, solid, covered at first by a hyaline glutinous sheath, whitish, in age tinted like the pileus from the drying veil, white within; spores ellipsoid, smooth, hyaline (12) 14—18 (20)  $\times$  7—9 $\mu$ ; basidia four-spored; gill-trama of divergent hyphae.

Scattered or solitary, rarely subcespitose on humus or mossy areas in dense conifer forests, Lake Quinault, Wash., Nov. 2—5, 1925, C. H. Kauffman. In his notes Kauffman pointed out that this species belonged in the subgenus *Limacium* and close to *H. olivaceoalbus*. It has the same stature as the slender variety of the latter, but lacks the peronate sheath of fuscous fibrils beneath the gluten on the stipe, possesses a glabrous pileus and much larger spores borne on four-spored basidia.

18. *HYGROPHORUS TEPHROLEUCUS* Fr. Plate 9.

Pileus 1—3 cm. broad, convex to plane, occasionally slightly depressed, not umbonate, viscid, appearing appressed fibrillose under the gluten, in age appressed scaly, pallid cinereous near the margin, dark ashy gray over the disc, fading to pale ashy gray over all in age; flesh whitish, soft, thin, odor and taste not distinctive; lamellae white, becoming creamy in age, adnate, becoming decurrent, subdistant, broad; stipe 4—6 cm. long, 2—3 (4) mm. thick, equal, solid, white within, white fibrous punctate near

the apex, more or less fibrillose below, base in young specimens coated with a thin layer of gluten, soon dry, white over all at first, the fibrils over the upper part cinerascens and dark gray in age; spores  $8-10 \times 4-5\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

It has been found in sphagnum bogs in Michigan. This material corresponds well to the descriptions of most European investigators. Nüesch (14) describes the stipe as dry. The thin layer of gluten disappears very soon, and, depending on weather conditions, one might describe the stipe as viscid on one occasion and as dry on the next. Consequently the above mentioned discrepancy is not serious. The outstanding characters are the ash colored pilei, and the fibrils on the stipe which are typically white but soon change to gray. Konrad (7) apparently believes that *H. olivaceoalbus* var. *gracilis* is the fungus Fries described under the name *H. tephroleucus*. It remains to be seen whether or not this concept will be generally accepted by European investigators. Konrad would very likely place the species here described as *H. tephroleucus* under *H. pustulatus*. The pilei of the California collection of the latter, however, were not as fibrillose as those of *H. tephroleucus* and the stems were punctate above as in *H. pudorinus* rather than furnished with fine fibrillose points as in *H. tephroleucus*.

19. *Hygrophorus tephroleucus* var. *aureo-floccosus* var. nov.

Pileus 1.5—3.5 cm. latus, convexus, explanatus vel umbonatus, pallide fuscus, glaber vel squamulosus, viscidus; caro alba, inodora, sapore miti: lamellae subdecurrentes, subdistantes, albae; stipes 2.5—7 cm. longus, 3—8 mm. crassus, sursum albidus et aureo-squamulosus, solidus, viscidus; sporae  $9-10 \times 5-5.5\mu$ . Specimen typicum legit prope Knoxville, Tenn., Dec. 2, 1934, L. R. Hesler n. 4466, in Herb. Univ. of Tennessee conservatum.

Pileus 1.5—3.5 cm. diameter, convex or convex-campanulate, then convex-expanded, usually umbonate, "Deep Mouse Gray" to "Hair Brown" at times, when covered by leaves almost white, umbo often darker, appearing innately squamulose or glabrous, often pustulate, viscid, margin involute, even or crenulate, fibrillose or floccose; flesh white, often water soaked, rather thin, odor and taste mild; lamellae white, adnate to subdecurrent, subdistant, subarcuate then plane, moderately broad; stipe 2.5—7 cm. long, 3—8 mm. thick, usually flexuous, equal or tapering downward, often curved at the base, apex white, base white or at times yellowish, elsewhere concolorous with the pileus or paler, floccose-squamulose or scabrous, tips of scales golden yellowish at first, then ashy gray to ashy brown or darker, viscid, stuffed solid, becoming hollow; spores  $9-10 \times 5-5.5\mu$ , ovate-ellipsoid or nearly pip-shaped, apiculate; basidia four-spored;  $47-63 \times 7-9\mu$ ; gill-trama of divergent hyphae.

This variety has been found only in Tennessee. The golden yellow tips

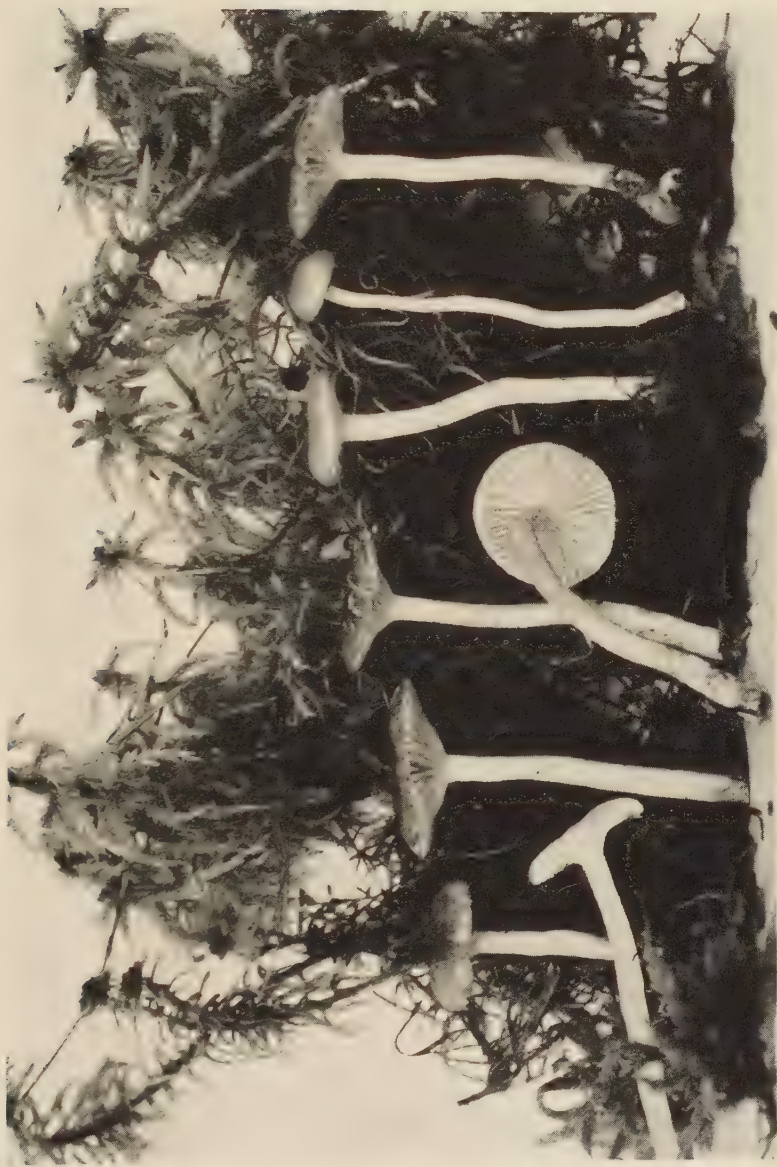


Plate 9, *Hygrophorus tephroleucus* Fr. xi.



of the scales over the upper portion of the stipe distinguish it at once. The change in color which they undergo indicates a relationship of the variety to *H. tephroleucus* rather than to *H. pustulatus* although the pileus surface has the characters of both.

20. *HYGROPHORUS PUSTULATUS* Fr.

Pileus 2—4.5 cm. broad, convex, at times papillate, margin inrolled and cottony when young, becoming plane, arched at maturity, viscid, glutinous when wet, ashy with a darker brownish disc (near "Buffy Brown"), somewhat virgate with radiating fibrils, opaque; flesh soft and white, rather thin, tapering slightly to the margin, odor and taste not distinctive; lamellae close to subdistant, bluntly adnate, becoming somewhat decurrent, narrow (4—5 mm.), pure white, stipe 6—9 cm. long, 5—8 mm. thick, equal or slightly enlarged below, solid or stuffed at the apex, lower portion subviscid to viscid from the remains of a thin gelatinous universal veil, whitish, dry and covered by dark gray punctate points above; spores  $7-9 \times 4-5\mu$ , narrowly ellipsoid; basidia four-spored; gill-trama of divergent hyphae.

Gregarious in an old trail under fir and redwood, Trinidad, California. For comments on this species see *H. tephroleucus*.

21. *HYGROPHORUS MULTIFOLIUS* Kauffman, Pap. Mich. Acad. Sci. 5: 131. 1926.

"Pileus 1.5—4 cm. broad, pliant, at first broadly convex and discoid, at length plane to depressed with a small umbo and a decurved margin, viscous, with a thin separable pellicle, soon dry and subtomentose, putty-colored to "drab" (R), margin at first incurved and persistently translucent-striatulate, incurved portion subtomentose; flesh rather thin, 1.5 mm. near stem, tapering gradually to margin, concolor, fading. Gills adnate-subdecurrent, at length decurrent by elevation of cap-margin, narrow, 3—4 mm., almost linear, close to subcrowded, "echru-drab" (R) or paler, waxy, edge entire. Stipe 3—5 cm. long, 2—3.5 mm. thick, equal, terete or compressed, hollow, slightly viscid when fresh from the thin hyaline evanescent universal veil, sometimes white-silky or lacerate-silky in upper portion, "light drab" (R) within and without, fading, toughish. Odor strongly farinaceous, taste similar. Spores suboblong, smooth, hyaline,  $6-6.5 (7) \times 3-3.5\mu$ . Sterile cells on edge of gills inconspicuous. Gill trama with parallel-diverging hyphae, those in the axis parallel."

Gregarious to subcespitose on deep moss in a hemlock, cedar and fir forest. Kauffman recognized its resemblance to species of the genus *Clitocybe*. We have not seen fresh material, and include it here on the basis of Kauffman's study. The basidia of the type measure  $22-24 \times 5-6\mu$ , and are four-spored. A thin gelatinous pellicle covers the pileus.

The short basidia indicate a closer relationship with *Clitocybe* than with *Hygrophorus*, but fresh material should be studied before making any change in its generic position.

Subsec. *Brunnei*

In this subsection are arranged three species which are characterized by their cinnamon brown, reddish brown or incarnate tan pilei and vivid stipes.

22. *HYGROPHORUS DISCOIDEUS* Fr.

Pileus 2-4 cm. broad, convex or with a slight umbos at first, at maturity with a decurved margin and the disc flattened or umbonate, at times with an elevated margin in age; glutinous to viscid, glabrous or faintly downy near the margin at first, "Hazel" to "Chestnut" on the disc, "Salmon-Buff" to "Ochraceous Buff" near the margin, scarcely fading; flesh thin, whitish or tinged testaceous, odor and taste not distinctive; lamellae whitish or tinged pinkish tan, close to subultrant, narrow, decurrent, stipe 4-9 cm. long, 3-5 mm. thick, equal, solid, becoming hollow, evenly white fibrillose above, slightly viscid below from the scant remains of a distinct gelatinous universal veil, upper portion covered with white fibrillose points, white over all, occasionally with gillvous stains at the base; spores 5.5-6.5  $\times$  4 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Scattered to gregarious under conifers and in sphagnum bogs, Michigan, Ontario, Colorado and Oregon.

In the American collections the spores seldom measure more than 7 $\mu$  long. A specimen of this species collected in Sweden by Lundel has spores practically the same size (6-7  $\mu$ ). The only macroscopic difference between the two is in the thicker stipe of Lundel's specimen. Brexidola's (2) description and illustration correspond with the American material in all respects except spore size (7-9 $\mu$ ). Konrad (6) describes *H. discoideus* as having spores 6-8  $\times$  4-5  $\mu$ , but does not give the dimensions of the stipe in his description. European investigators agree that *H. discoideus* favors a coniferous habitat, a characteristic also constant of our specimens. The collection reported for Michigan by Smith (20) did not show the gillvous staining on the stipe as described by Brexidola but this character has been noted in subsequent collections.

23. *HYGROPHORUS VARICOLOR* Murr. Plate 10.

Pileus 4-7 cm. broad, obtuse at maturity slightly umbonate, sometimes plane and with a decurved margin; glutinous, more or less fibrillose streaked beneath the gluten, margin cottony tomentose and often beaded with drops of moisture. "Tawny" to "Cinnamon Brown" on the disc, paler tawny toward the whitish margin, flesh white, thick on the disc.

firm, taste mild, odor of almonds when cut or bruised; lamellae pure white, close to subdistant (58—70 reach the stipe) bluntly adnate but soon short decurrent, equal, narrow (3—4.5 mm.); stipe 8—10 cm. long (3—5 cm. in alpine forms), 10—15 mm. thick at the apex, gradually tapered to a long pointed subradicating base, solid, lower portion glutinous from the remains of a gelatinous universal veil, appressed fibrillose beneath the gluten, the upper half dry and pruinose to minutely white fibrillose-furfuraceous, often beaded with drops of moisture near the apex, pure white over all or the base discolored slightly; spores 7—9  $\times$  5—6 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

This species is related to *H. discoideus* but differs in its size and in the more yellowish brown colors. It also resembles *H. laurae* in certain respects, but the color changes in drying separate the two at once. When properly dried the gills of *H. laurae* do not become reddish brown. *H. arbustivus* Fr. sensu Rea is apparently the nearest European species. Rea's (16) description is very suggestive of Murrill's species. The outstanding character of *H. arbustivus* is said to be that the apex of the stipe is covered by white free mealy granules. Murrill described the stipe as pulverulent, and the veil as represented by a few short brownish fibrils at the center of the stipe. A study of Murrill's type, however, shows that it is the species we have described above in spite of any apparent discrepancies in the original description. The glutinous veil may be present only around the base of the stipe and under unfavorable conditions might be easily overlooked. The difference between the pruinose to furfuraceous particles on the stipe of one and the free mealy granules on the other might easily be a difference of interpretation. However, in the absence of specimens of *H. arbustivus* for comparison, and due to conflicting opinions as to its characters among European investigators, we prefer to use the name given to the American material.

#### 24. *Hygrophorus subsalmonius* sp. nov. Plate 11.

Pileus 4—12 (15) cm. latus, convexus, demum explanatus, glutinosus, glaber, margine fibrillosus, rufus vel ferruginus, demum subsalmonius; caro albidā vel sordide incarnata, inodora, sapore miti; lamellae pallide incarnatae demum subsalmoniae, decurrentes, subdistantes, latae; stipes 3.5—8 (10) cm. longus, 1—3.5 cm. crassus, solidus, equaliter vel deorsum attenuatus, glutinosus, sursum squamulosus, albidus, demum subsalmonius; sporae 6.5—8  $\times$  4—5 $\mu$ ; basidia tetraspora. Specimen typicum legit prope Ann Arbor, Mich., Oct. 23, 1936, A. H. Smith n. 6143 in Herb. Univ. of Michigan conservatum.

Pileus 4—12 (15) cm. broad, convex, becoming plane or in age with an elevated margin and a depressed disc, surface very glutinous in wet weather, merely viscid in age, glabrous except for a cottony fibrillose mar-





Plate 10, *Hygrophorus variicolor* Murr. x1.

gin, colors "Ferruginous" to "Rufous" on the disc, paler and "Salmon-Buff" on the margin, in age fading to "Salmon-Buff" or "Apricot-Buff" over all; flesh thick, firm, white or at times faintly tinged sordid incarnate, odor and taste not distinctive; lamellae "Pale Pinkish Buff," darker incarnate tan in age or when decaying, adnate, usually becoming decurrent, close to subdistant, moderately broad, edges even; stipe 3.5—8 (10) cm. long, 1—3.5 cm. thick, solid, equal or with a flaring apex and a narrowed base, basal portion glutinous from the remains of the thick gelatinous universal veil, surface minutely squamulose above the viscid portion, whitish or tinged incarnate tan, the color often deeper in age; basidia four-spored; spores  $6.5-8 \times 4-5\mu$ , ellipsoid, smooth, hyaline; gill-trama of divergent hyphae.

Gregarious under oak and hickory or in brush along roadsides, Michigan, Iowa, and Tennessee.

It is most closely related to *H. glutinifer* Fr. Since the latter is considered by some to be the same as *H. pudorinus* Fr. and since those who recognize *H. glutinifer* attribute to it certain characters which the American collections do not have, it seems best to describe ours as new. Nüesch (14) describes the flesh of *H. glutinifer* as orange to reddish orange throughout, the spores as  $8-11 \times 5-6\mu$ , and the glutinous veil as soon disappearing. In ours the glutinous veil is very thick and persistent, the spores from deposits measure  $6.5-8 \times 4-5\mu$ , and the flesh of the pileus is white or only faintly tinged pale incarnate. When dried, the squamules over the upper portion of the stipe become pale orange, but never form reddish punctate spots as in *H. pudorinus*.

#### Section CLITOCYBOIDES

##### Subsec. *Pallidi*

White or nearly white species with dry stipes are placed in this subsection. The pileus of *H. pusillus* usually has a creamy to pale tan disc and a broad white marginal area.

#### 25. *HYGROPHORUS SORDIDUS* Pk. Plate 12.

Pileus 8—20 cm. broad, convex then expanded plane, firm, viscid, pure white or rarely tinged yellowish buff on the disc, glabrous, even, margin at first involute and subfloccose; flesh moderately compact, thick, white, odor and taste mild; lamellae adnate to decurrent, subdistant, rather broad, acuminate at the ends, white, slightly yellowish in age, waxy, sub-intervene; stipe stout, 6—10 cm. long, 15—30 mm. thick, usually short, solid, dry, equal, often attenuated toward the base, white, glabrous, even, upper portion obscurely floccose; spores ellipsoid, smooth,  $6-8 \times 4-5\mu$ ; basidia four-spored; gill-trama of divergent hyphae.

Gregarious in open oak-hickory woods late in the fall, Michigan.



Plate 11, *Hygrophorus subsalmonius* Smith & Hesler xi.



Peck recognized the close similarity of this species to *H. penarius* Fr. It differs from the latter in the absence of a gelatinous universal veil, the typically white gills and pileus, and obscurely floccose apical region of the stipe. *H. penarius* has been reported for the United States, and very likely does occur here. Forms which apparently were this species have been found in Michigan but not in sufficient quantity or in good enough condition to justify a critical study.

26. *HYGROPHORUS ALBIDUS* Karst.

Pileus 1—4 cm. broad, convex, becoming plane or with an uplifted margin, viscid, innately appressed fibrillose under the viscosity, snow white over all; flesh soft, white, odor and taste not distinctive; lamellae snow white, subdistant (25—30 reach the stipe), broad, adnate, decurrent in age, some forked near the margin of the pileus, rather thin, edges even; stipe 3—5 cm. long, 3—5 mm. thick, hollow, tapering downward, moist to dry (no gelatinous veil present in button stage) glabrous over lower half, upper half covered by a white cottony fibrillose coating, apex not scabrous; spores 6—7.5  $\times$  4—5 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

This very rare species was found once in a dense stand of second growth spruce in a swampy area in northern California. The divergent hyphae of the gill-trama at once separate it from various white species of the subgenus *Camarophyllus*. It is entirely possible that *H. albidus* is "rare" because collectors have passed it by thinking it was one of the more common species such as *H. borealis* Pk. or *H. niveus* Fr.

27. *HYGROPHORUS PUSILLUS* Pk. Plate 13. (Large specimens.)

Pileus 2—4 (5) cm. broad, broadly convex, soon flattened, the margin often elevated in age and plicate-crenate, surface viscid, glabrous, white or disc tinged creamy yellow to pale incarnate tan; flesh soft, white, thin, taste mild, odor faintly but distinctly aromatic; lamellae white to creamy white, subdistant (24—30 reach the stipe), two rows of short gills present near the margin, adnate, becoming short decurrent, thickish, some forking; stipe 4—7 cm. long, 4—8 mm. thick, equal above a narrowed base, solid, flesh white, dry, glabrous or the apex very faintly fibrillose-pruinose, white; spores 7—9  $\times$  4—5 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Scattered or in troops under spruce and fir, California, Oregon, Washington, Idaho and New York. In Europe *H. russo-coriaceus* seems to be very similar. Bataille (1) and Nüesch (14) place the latter in *Limacium* but Lange (9) places it in the subgenus *Camarophyllus*. Peck's species is without question a *Limacium*, and differs from descriptions of the European species in its slightly colored pilei. Kauffman collected it in New York and Washington, and Smith found it growing in great quantities in southern Oregon and northern California.



Plate 12, *Hygrophorus sordidus* Pk. XI.

Subsec. *Fulvo-incarnati*

This group is composed of flesh-colored, pinkish tan, tawny or dark brown species with dry stipes. Most of them are large fleshy forms without any pronounced odor or taste.

28. *HYGROPHORUS PUDORINUS* Fr.

Pileus 5—10 (12) cm. broad, firm, convex to campanulate, obtuse or subexpanded, pale tan to pinkish buff or pale flesh color, glabrous, even, viscid, margin at first involute and minutely white downy; flesh compact, thick, white or tinged incarnate, odor and taste not distinctive; lamellae acuminate, subdecurrent, narrow, subdistant, thickish, sometimes forked, intervenose, white to pallid or sometimes tinged pale incarnate but never reddish-spotted; stipe 4—9 cm. long, 10—20 mm. thick, equal or tapering downward, stout, dry, solid, compact, white to buff or incarnate tinged, upper portion, white floccose-punctate, the scales or points becoming reddish in age or as the fruiting body dries, more or less appressed fibrillose toward the base, typically dry but sometimes subviscid to the touch when the basal portion becomes water-soaked; spores 6—9  $\times$  4—5 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Scattered to gregarious in bogs or in mixed coniferous forests, Michigan, Ontario and New York.

We are basing our concept of this species on that of Kauffman (4). Most investigators, including Peck (15) in the United States, have described the stipe as viscid. In our collections from the areas cited above we were unable to demonstrate the presence of a gelatinous sheath at any stage of development. At times however, the fibrillose covering at the base of the stipe may become quite moist or water-soaked, and under such conditions the hyphae gelatinize slightly producing a slight stickiness. A similar condition has been noted in species of *Cortinarius* of the subgenus *Inoloma*, Smith (21). This should not be regarded as true viscosity. Since dried specimens of both ours and Kauffman's collections compare very well with those in Peck's herbarium as well as with material from Dr. Rolf Singer from the U. S. S. R. we have designated them *H. pudorinus*. For additional comments see *H. fragrans* Murr.

29. *HYGROPHORUS FRAGRANS* Murr. Plate 14.

Pileus 7—20 cm. broad, convex, becoming plane or with a slightly up-lifted margin, margin remaining inrolled and downy pubescent until maturity, surface glutinous, becoming viscid, somewhat felty fibrillose under the gelatinous pellicle, color "Apricot Orange" to "Salmon Color" on the disc, "Seashell Pink" or paler near the margin, not fading appreciably; flesh "Pale Salmon Color" in the pileus, white in the stipe, staining yellow and finally orange when bruised, taste mild, odor faintly fragrant; lamel-





Plate 13, *Hygrophorus pusillus* Pk. x1, large specimens.

lae "Pale Pinkish Buff" to "Pale Pinkish Cinnamon," never truly white, adnate, thin, close, becoming subdistant (60–80 reach the stipe), moderately broad (1–1.5 cm.); stipe 10–20 cm. long, 1.5–3.5 cm. thick, narrowed to a point at the base, solid, surface dry, fibrillose over lower half, scabrous-punctate and often beaded with drops over the upper half, color white or flushed with pink, base "Ochraceous-Buff" to "Zinc Orange" inside and out; spores  $7-9 \times 5-5.5\mu$ , ellipsoid, smooth, hyaline; gill-trama of divergent hyphae.

Smith has studied this species in great detail both in favorable and unfavorable seasons along the Pacific coast. It is usually found growing gregariously under spruce, and appears to be very close to if not identical with *H. pudorinus* as that species is known in eastern United States. It differs, apparently, in the bright ochraceous base of the stipe, the pronounced tendency to stain yellow and finally orange when bruised, and the pinkish buff to pinkish cinnamon gills. Fruiting bodies in all stages of development have been studied, and no indications of a gelatinous universal veil were present. It is interesting to note that in many respects this western species corresponds to Fries' description of *H. pudorinus* better than does the *H. pudorinus* of eastern United States or of most European authors. Fries (1821) described the stipe as "glaber," obviously referring to the lack of a veil. Later (1836–38) he stated "Proximus *H. eburneo*, sed firmior, stipite sicco glabro et colore uniformi r. lutescenti-maculoso distinctus. Cortina nulla." In 1874 he stated of the stipe "vellum nullum. Pileus non pelliculosus, interdum (ut caro alba) luteo-maculatus." It is difficult to understand why a species with a distinct gelatinous universal veil has been referred to *H. pudorinus* by certain European investigators. The colors as Fries described them, the tendency to stain yellow, and the stipe characters of both *H. pudorinus* Fr. and *H. fragrans* Murr. are practically identical. The color of the gills in the latter might serve to separate it. Because of the confusion which exists in regard to the identity of the supposedly well known *H. pudorinus*, Murrill's species is retained at least for the present.

### 30. *Hygrophorus fragrans* f. *pallidus* f. nov.

Pileus 5–9 cm. latus, convexus, pallide alutaceus, viscidus, lamellae albae, confertae vel subdistantes latae, adnatae vel subdecurrentes; stipes 10–18 cm. longus, 1–2.5 cm. crassus, solidus, equaliter vel subventricosus, sursum floccoso-punctatus, albidus demum luteo-maculatus; sporae  $8-10 \times 5-6\mu$ . Specimen typicum legit prope Trinidad, Calif., Dec. 1, 1935, A. H. Smith n. 3685, in Herb. Univ. of Mich. conservatum.

Pileus 5–9 cm. broad, convex with an inrolled margin, surface viscid, glabrous or faintly fibrillose-streaked beneath the gluten, margin cottony tomentose, at first "Warm Buff" on the disc and nearly white on the

margin, fading in age to "Pinkish Buff" on the disc and becoming "Cartridge Buff" or more sordid on the margin, gluten sometimes forming yellowish sordid patches over the surface, flesh thick, white, changing to



Plate 14, *Hygrophorus fragrans* Murr. xi.

delicate pink under the cuticle or around the edges of the worm holes, fragile, taste mild, odor faintly fragrant, lamellae white, close to subdistant, broad (1—1.3 cm.), bluntly adnate, becoming subdecurrent; stipe 10—18 cm. long, 1—2.5 cm. thick, solid, equal to subventricose, whitish



within, surface densely white floccose-squamulose above, appressed fibrillose below, slightly viscid at the base when wet, white over all, base staining rusty yellow; spores  $8-10 \times 5-6\mu$ , ellipsoid, smooth, basidia four-spored; gill-trama of divergent hyphae.

Since first collecting this form under spruce in northern California, *H. fragans* has been found in great abundance, and was never observed to change to the colors described above. It thus seems advisable to consider collection 3685-S as representing a distinct color form of the species.

30a. **Hygrophorus subisabellinus** sp. nov.

Pileus 4.5—7 cm. latus, convexus demum planus vel umbonatus, glaber, viscidus, subisabellinus; caro albida, inodora, sapore miti; lamellae adnatae demum subsinuatae, angustae, albae, confertae; stipes 4—9.5 cm. longus, 5—12 mm. crassus, albidus, deorsum subisabellinus, siccus, sursum squamulosus, solidus, equaliter vel deorsum attenuatus; sporae  $6-7.5 \times 3.5-4\mu$ ; basidia tetraspora. Specimen typicum legit prope New Hopewell, Knox Co., Tenn., May 26, 1938, A. J. Sharp, in Herb. Univ. of Tennessee conservatum.

Pileus 4.5—7 cm. broad, hemispheric-convex then expanded, obtusely umbonate, glabrous but under a lens with a mat of closely woven fibrils, viscid when wet, "Pinkish Buff" to "Cinnamon-Buff," margin usually somewhat paler as well as involute and downy; flesh white, 10 mm. thick on the disc, thin on the margin, odor and taste mild; lamellae adnate, becoming slightly notched, close, narrow, tapering at either end (4 mm. broad in midportion), white, edge even; stipe 4—9.5 cm. long, 5—12 mm. thick, white, dingy below (almost concolorous with pileus), dry, upper portion floccose-scabrous, solid, flexuous, equal or tapering toward the base; spores  $6-7.5 \times 3.5-4\mu$ ; basidia  $40-57 \times 7\mu$ , four-spored; trama of gills of divergent hyphae  $7-14\mu$  in diameter.

Gregarious on humus in woods, New Hopewell, Knox Co., Tenn., May 26, 1938 (collected by A. J. Sharp), and Feb. 22—29, 1939 (collected by L. R. Hesler). The mild odor and taste and paler colors separate it readily from *H. tennesseensis*. It lacks the dense pruinose covering of the stipe of *H. roseibrunneus* as well as the pinkish tan colors of the dried specimens of the latter. The close gills and innate squamules over the upper part of the stipe distinguish it from *H. arbustivus* Fr. From pale forms of *H. pudorinus* it is readily distinguished in the dried condition by the lack of reddish punctate points over the upper portion of the stipe.

31. **Hygrophorus tennesseensis** sp. nov.

Pileus 2—12 cm. latus, convexus demum explanatus vel subdepressus, isabellinus vel margine pallidus, viscidus, glaber; caro alba, firma, sapore amara, odore distinctissima; lamellae adnatae demum decurrentes, sub-

distantes, latae, albae; stipes 6—10 cm. longus, 8—10 mm. crassus, solidus, pallidus, siccus, fibrillose striatus, sursum floccoso-scabrus, deorsum attenuatus; sporae  $6.5-9 \times 4-5\mu$ ; basidia tetraspora. Specimen typicum legit prope Cades Cove, Tenn., Oct. 17, 1937, L. R. Hesler n. 10922, in Herb. Univ. of Tennessee conservatum.

Pileus 2—12 cm. broad, convex then expanded, becoming depressed, marginal portion whitish to "Clay Color" or "Tawny-Olive," central portion "Tawny" to "Fawn Color," viscid or glutinous, glabrous, margin even or substriate, involute, floccose-fibrillose, pellicle separable to disc;



Plate 15, *Hygrophorus roseibrunneus* Murr. xi.

flesh white, thick (up to 8 mm. at disc), thin at margin, compact, odor distinct, somewhat resembling that of raw potatoes, taste bitter; lamellae adnate to decurrent; white, linear, about 7 mm. broad, subdistant, many are short, venose at cap; stipe 6—10 cm. long, 8—18 mm. whitish or dingy, dry, solid, more or less flexuous, tapering downward, fibrillose-striate, upper portion floccose-scabrous; spores  $6.5-9 \times 4-5\mu$ , ellipsoid, apiculate; basidia  $38-47 \times 6-8\mu$ , four-spored; gill-trama of divergent hyphae, cells  $5-9\mu$  dia.

The odor, taste, colors, dry stipe and resemblance to *H. pudorinus* in stature are the distinctive features of this species. In its colors it closely resembles *H. variicolor* Murr. but its dry stipe and bitter taste distinguish it at once. The brown pilei and bitter taste distinguish it at once. The brown pilei and bitter taste distinguish it readily from *H. pudorinus*. *H. arbustivus* Fr. sensu Nüesch (14) is also closely related but differs in its virgate pileus and mild odor and taste. In addition other investigators have usually described the pileus of the latter as more reddish or incarnate tan.

32. *HYGROPHORUS ROSEIBRUNNEUS* Murr. Plate 15.

Pileus 2—5 cm. broad, convex, becoming broadly umbonate or sub-turbinate, sometimes flattened and with a decurved or elevated margin, subglutinous to viscid, appearing agglutinated fibrillose near the cottony tomentose inrolled margin, somewhat streaked toward the disc, "Light Vinaceous-Cinnamon" to "Vinaceous-Buff" on the disc, paler and "Pale Pinkish Cinnamon" or "Pale Pinkish Buff" near the margin; flesh white, soft, thickish, odor and taste not distinctive, no color change when bruised; lamellae white, close to crowded (50—60 reach the stipe), thin, moderately narrow, adnate, in age becoming slightly decurrent, many short ones present; stipe 3—6 cm. long, 4—9 mm. thick, equal or tapering slightly toward the base, stuffed-solid, dry, white fibrillose-punctate to densely pruinose from a dense covering of small white to pinkish buff squamules, subglabrous toward the base; spores 7—9  $\times$  4—5 $\mu$ , ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Gregarious under oak, fir and pine, Michigan and California. In Michigan it has been found in oak woods and in mixed oak-pine plantations. In California Murrill (12) reported it throughout the state under oak. Smith has collected it under mixed live oak and fir in northern California. Kauffman (4) at first considered this to be a small form of *H. pudorinus*, but later in his notes indicated that he considered it distinct. The brownish to pinkish brown virgate pilei with more or less tomentose margins when young, the stature, and the densely pruinose-punctate upper portion of the stipe all strongly point to a relationship with *H. arbustivus* Fr. sensu Quélet. The thin close to crowded lamellae and possibly the dry stipe distinguish the American species.

33. *Hygrophorus pacificus* sp. nov. Plate 16.

Pileus 3—8 cm. latus, convexus, demum planus, saepe plicatus, viscidus, glaber, fulvus; caro pallida, odore aromatica, sapore miti; lamellae pallide luteae, distantes, latae, adnatae; stipes 4—7 cm. longus, 8—15 mm. crassus, equaliter, solidus, pallide luteus vel sordide albidus, sursum pruinosis; sporae 11—14  $\times$  6—8 $\mu$ ; basidia tetraspora. Specimen typicum legit prope Fort Dick, Calif., Nov. 14, 1937, A. H. Smith n. 8732, in Herb. Univ. of Michigan conservatum.

Pileus 3—8 cm. broad, convex, margin long remaining incurved, becoming plane and variously lobed, notched or wavy in age, margin usually plicate crenate when unexpanded, viscid, glabrous, margin faintly tomentose under a lens, colors evenly "Russet" to "Tawny" when young, at maturity "Tawny" on the disc and "Pinkish Buff" on the margin; flesh whitish, rather thin and rigid, taste mild, odor strong, penetrating and aromatic; lamellae "Margurite Yellow" to "Cream-Buff" when young, "Cream Color" in age, distant, broad (1 cm.), often forking near





Plate 16, *Hygrophorus pacificus* Smith & Hesler xi.

the margin of the pileus, thickish, bluntly adnate or decurrent by a tooth, edges even; stipe 4—7 cm. long, 8—15 mm. thick, equal above a narrowed base, solid or sometimes hollowed at the apex, concolorous with the lamellae or whitish, dry, evenly fibrillose-pruinose over upper half with whitish fibrils, glabrous and unpolished below; spores  $11-14 \times 6-8\mu$ , subellipsoid, hyaline, smooth; basidia four-spored; gill-trama of divergent hyphae.

Densely gregarious under spruce, in California and Washington. During the season of 1937 this species was very abundant in the vicinity of Fort Dick, Calif. Kauffman collected it in Washington in 1925. The large spores, dry stipe, russet to tawny colors, mild taste and strong aromatic odor distinguish it. Kauffman tentatively referred it to *H. agathosmus* as a variety. It does resemble that species in having an odor and a dry stipe, but the colors of both the pileus and gills, and the large spores amply distinguish it. It is apparently very closely related to the little known *H. aromaticus* (Sow.) Berk. The latter apparently differs in its narrow, white to pink gills, and the flesh which is said to turn blackish when bruised.

34. **Hygrophorus Kauffmanii** sp. nov. Plate 17.

Pileus 4—11 cm. latus, obtusus demum turbinatus, canus demum glaber, viscidus, testaceus demum pallidus; caro firma, inodora, sapore miti; lamellae testaceae, subdistantes, decurrentes; stipes 4—10 cm. longus, 1—2 cm. latus, deorsum attenuatus, siccus, glaber, apice subsquamulosus. solidus; sporae  $7-8 \times 4-5\mu$ ; basidia tetraspora. Specimen typicum legit prope Ann Arbor, Mich., Oct. 13, 1936, A. H. Smith n. 6406, in Herb. Univ. of Michigan conservatum.

Pileus 4—11 cm. broad, turbinate to plane with a slightly elevated margin in age, surface with a thin coating of appressed hoary fibrils which sometimes become aggregated into minute spot-like scales, usually appearing canescent and glabrous to the naked eye, viscid to subviscid, margin incurved and minutely tomentose, color "Chestnut" when moist, usually appearing "Pecan Brown" or "Vinaceous-Tawny," in age fading to "Apricot Buff"; flesh firm, "Light Pinkish Cinnamon" in color or darker when moist, thick on the disc, tapering abruptly, odor and taste not distinctive; lamellae "Onion-skin Pink," becoming "Kaiser Brown" to "Cameo Brown," subdistant, fairly broad, decurrent; stipe 4—10 cm. long, 1—2 cm. thick, enlarged upward, solid, no evidence of a glutinous veil at any stage, surface glabrous or at times subsquamulose at the apex, "Buff-Pink" at first, soon concolorous with the pileus or darker, canescent; spores  $7-8 \times 4-5\mu$ , ellipsoid, smooth, hyaline; basidia four-spored; gill-trama of divergent hyphae.

Gregarious to scattered in open oak woods, Ann Arbor, Mich. Kauffman



Plate 17, *Hygrophorus Kauffmanii* Smith & Hesler xi.



collected this species many years ago, and in the Agaricaceae of Michigan, p. 188, described it under the name *H. leporinus*. Kuhner (8) stated that the *H. leporinus* of Kauffman is the same as *H. nemoreus* as the latter is known in Europe. However, if the descriptions of *H. nemoreus* are carefully examined, it becomes apparent that the latter differs from *H. Kauffmanii* in certain important respects. Bataille (1) described the gills of *H. nemoreus* as "blanches, puis creme, a reflet aurore." Bresadola (2) figured a species which has the gill characters as Bataille described them. Nüesch (14) also describes the gills of *H. nemoreus* as essentially pale ("blass cremfarbig bis rotlich ocherfarbig oder blassorange"). He also describes the stipe as whitish to pale ochraceous, colors strikingly different from the buff pink to chestnut color of the stipe of *H. Kauffmanii*. Ricken's (17) description and illustration are in accord with those mentioned above, and Rea's (16) apparently applies to still a different species because of its spores. Lange (9) describes a form he referred to *H. nemoreus* as a variety as having a white stipe, and gills paler than the pileus. If descriptions can be relied upon, the dark reddish brown gills of *H. Kauffmanii* amply distinguish it.

Subsec. *Erubescentes*

The reddish spots which soon develop on the lamellae, the dry stipe and the more or less pinkish red to yellowish colors distinguish the species of this subsection.

35. *HYGROPHORUS RUSSULA* (Fr.) Quél. Plate 18.

Pileus 5—12 cm. broad, hemispheric or convex, sometimes broadly umbonate, becoming expanded in age and often with an elevated margin, margin long remaining inrolled and finely cottony pubescent, surface viscid but soon dry, pellicle scarcely separable, color whitish to "Chatenay Pink" near the margin and occasionally with darker purplish red rounded spots, disc more or less "Indian Lake," darker wine color or purplish red, usually streaked with purplish red fibrils around the disc, surface smooth at first but breaking up into minute appressed fibrillose patches giving the disc a granulose to subscaly appearance, when rubbed sometimes staining yellowish (the colors vary and may be "Shrimp Pink," "Cameo Pink," "Coral Pink," "Vinaceous-Pink" or "Deep Vinaceous"); flesh thick (1—1.7 cm. near the stipe), white or tinged pinkish, firm, odor and taste mild; lamellae close to crowded, 120—130 reach the stipe, thin, in 3 or 4 tiers, bluntly adnate, becoming decurrent, narrow to moderately broad (4—7 mm.), acuminate at the ends, white when young, soon flushed with pale pink and later spotted with sordid purplish red spots, sometimes sordid purplish red over all in age; stipe 3—8 cm. long, 1—3 cm. thick, equal or slightly tapered toward the base, at times subventricose, solid, dry, apex pruinose to glabrous, glabrous below, white at first, becoming



Plate 18, *Hygrophorus Rassula* (Fr.) Quél. xi.

stained or laved with pinkish and finally more or less concolorous with the pileus; gill-trama of divergent hyphae; spores  $7-8 \times 4-5\mu$ , hyaline, ellipsoid; basidia four-spored, rarely two-spored.

In arcs in oak-hickory woods, Michigan and Tennessee. A very common species in eastern United States. *II. erubescens* is most closely related to it, but grows in coniferous woods, has fewer gills (75—95 reach the stipe), and the change to yellowish when bruised is more pronounced.

36. *HYGROPHORUS ERUBESCENS* Fr. Plate 19.

Pileus 5—12 cm. broad, convex, becoming umbonate or plane, margin incurved and minutely tomentose, surface glutinous or viscid, innately fibrillose beneath the gluten or in age with spot-like scales over the disc, color whitish near the margin, disc laved or splashed "Etruscan Red," fading to "Hydrangea Pink," a pink tinge often pervading the entire pileus, often beaded with drops of moisture on the margin; flesh white, thick, soft, often staining yellowish where bruised, odor and taste not distinctive; lamellae "Pale Pinkish Buff" but soon spotted or stained with pinkish red, close to subdistant (75—95 reach the stipe), adnate becoming decurrent, narrow, edges even; stipe 6—12 cm. long, 1—2 cm. thick, tapering downward to a somewhat pointed base, solid, surface dry, fibrillose pruinose and beaded with drops of moisture above, appressed fibrillose or slightly scurfy below, whitish or tinged "Shell Pink," yellowish when rubbed or bruised, base whitish; spores  $7-9 \times 5-6\mu$ , hyaline, ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Gregarious under conifers, especially spruce, in California, Oregon and Colorado (the last by C. H. Kauffman). It was very common in California during the 1937 season.

37. *Hygrophorus erubescens* var. *gracilis* var. nov.

Pileus 2—3 cm. latus, planus, glutinosus, sanguineo-roseus vel margine incarnatus; lamellae distantes, rubromaculatae; stipes 6—10 cm. longus, 4—8 mm. crassus, siccus, albus demum sordide roseus; sporae  $8-10 \times 5-6\mu$ ; basidia tetraspora. Specimen typicum legit prope Florence, Ore., Nov. 20, 1935, A. H. Smith n. 3564, in Herb. Univ. of Michigan conservatum.

Pileus 2—3 cm. broad, plane with a decurved margin, sometimes slightly umbonate, "Vandyke Red" on the disc and "Flesh Pink" toward the margin, margin incurved and white pruinose at first; flesh white, soft, odor and taste mild; lamellae whitish or flushed a grayish pink, staining reddish, distant, narrow, adnate, becoming decurrent; stipe 6—10 cm. long, 4—8 mm. thick, equal, base somewhat pointed, upper portion with minute white fibrillose scales or coarsely fibrillose-pruinose, appressed fibrillose below, dry, whitish, becoming purplish red in age; spores  $8-10 \times 5-6\mu$ , ellipsoid; basidia four-spored; gill-trama of divergent hyphae.





Plate 19, *Hygrophorus erubescens* Fr. XI.

Gregarious under pine, Florence, Ore., Nov. 20, 1935 (3564-S).

This variety is related to *H. erubescens* in the same way that the slender form of *H. olivaceoalbus* is related to that species. There seems to be a series of slender forms in this subgenus. The above variety differs from *H. erubescens* in its more distant gills and lack of yellowish stains when fresh as well as in stature.

38. *HYGROPHORUS PROXIMUS* Krieger, *Mycologia* 19:310. 1927.

"Pileus 5.5 cm. broad, slightly repand, pinkish creamy, and with a fine purplish-red scattered tomentum that forms darker spots of purple red on the moderately elevated disc; flesh very thin toward the margin. Gills very narrow and close, unequal, creamy white, markedly decurrent. Stem 5 cm. long, 1.2 cm. thick, tapering a little below, white, with a pinkish lavender tinge, slightly fibrillose with a few purplish fibrils, punctate above with pale tomentose dots. Flesh of stem and pileus solid and white, or very faintly pinkish. While drying, the plant emitted an odor of rancid lard. Spores hyaline,  $6.6 \times 4.4\mu$ ."

Collected at Belair, Md., Oct. 7, 1919, by Miss Olga E. B. Kelly, no. 287.

"It seems near *H. erubescens* Fries, hence the specific name. The gills of my plant are much closer and narrower, and the spores considerably smaller than in the Friesian species."

We include this species on Krieger's original description and comments. A portion of the type deposited in the University of Michigan Herbarium confirms Krieger's comments on the relationship of it to *H. erubescens*. The long-decurrent, narrow, crowded gills are very distinctive.

39. *Hygrophorus amarus* sp. nov.

Pileus 3—8 cm. latus, hemisphericus vel convexus, demum explanatus, glutinosus, pallide isabellinus vel luteo-incarnatus, margine albofloccosus; caro 5—10 mm. crassa, firma, inodora, sapore amara; lamellae adnatae demum subdecurrentes, confertae vel subdistantes, latae, pallide luteae demum incarnato-maculosae; stipes (5—7) 8—13 cm. longus, 10—15 (20) mm. crassus, basi attenuatus, albidus vel subincarnatus, fibrillose peronatus, siccus vel subviscidus; sporae 7—8.5  $\times$  4.5—6 $\mu$ ; basidia tetraspora. Specimen typicum legit prope Lake Quiniault, Wash., Nov. 2, 1925, C. H. Kauffman, in Herb. Univ. of Michigan conservatum.

Pileus 3—8 cm. broad, subhemispheric at first, then convex, expanded plane, obtuse or subdiscoid, glutinous, color varying from "Warm Buff" to "Flesh Color" at first, sometimes "Antimony Yellow" or tinged "Salmon Color" to "Ochraceous-Orange" on the disc, paler on the margin, not streaked, glabrous and even, margin at first incurved and white floccose; flesh 5—10 mm. thick on the disc, rather compact, white, unchanging, odor slight, taste very bitter to nauseous and persistent;

lamellae adnate, at length arcuate with a decurrent tooth, waxy, close to subdistant, rather broad (6—10 mm.), "Ivory Yellow," becoming incarnate spotted; stipe long or short, 5—7 cm. or 8—13 cm. long, 10—15 (20) mm. thick at the apex, tapering downward or attenuated at the base, white or tinged incarnate, covered throughout by an innate dense white floccose-fibrillose layer, dry or slightly viscid at first, solid; spores ellipsoid, smooth  $7-8.5 \times 4.5-6\mu$ ; basidia four-spored; gill-trama of divergent hyphae.

Gregarious to subcespitose under spruce and Douglas fir, Washington and Idaho. All of the collections were made by Prof. Kauffman and our description is taken from his notes. *H. erubescens* is sometimes described



Plate 20, *Hygrophorus capreolarius* Kalch. xi.

as being bitter. However, the combination of the colors of the pileus and gills, the very bitter taste, the stature which is similar to that of *H. pudorinus*, and the fibrillose sheath of the stipe distinguish Kauffman's collections.

40. *HYGROPHORUS CAPREOLARIUS* Kalchbr. Plate 20.

Pileus 3—6 (7) cm. broad, convex-expanded, obtuse or subumbonate, viscid, soon dry, "Vandyke Red" and unicolorous, delicately streaked with purplish fibrils, appressed scaly-dotted on the disc in age, the thick margin at first incurved and white silky; flesh rather thick, whitish, reddish or concolorous, odor and taste not distinctive; lamellae adnate, becoming decurrent, rather distant, broadest in the middle, narrowed at the ends, rigid, at first pallid, becoming flesh-color or dull pink, finally concolorous with the pileus, thickish, intervenose; stipe 3—6 cm. or 5—10 cm. long, 6—10 (12) mm. thick, equal or subventricose, innately pruinose-fibrillose, substrate, apex floccose-punctate, whitish with a reddish tinge at first,





Plate 21, *Hygrophorus purpurascens* Schw. xi.

becoming concolorous with the pileus, the apex usually remaining paler, veil lacking; spores ellipsoid, smooth, 7—9 (10)  $\times$  5—6 $\mu$ ; gill-trama of divergent hyphae.

Scattered under spruce and in sphagnum bogs, New York. We include this species on the basis of Kauffman's collections and one by Smith near Newcomb, N. Y. The darker colors of pileus and gills and lack of a fibrillose veil should distinguish it from the following.

41. *HYGROPHORUS PURPURASCENS* Schw. Plate 21.

Pileus (3) 6—12 (15) cm. broad, convex, becoming plane or turbinate, margin remaining decurved until late maturity, surface viscid due to a thin gelatinous pellicle, nearly dry in age, appressed fibrillose, margin cottony-fibrillose, sometimes becoming appressed scaly, color of fibrillose layer "Neutral Red," "Hellebore Red" or "Deep Livid Brown" on the disc, paler and near "Rhodonite Pink" on the margin, flesh beneath the fibrils whitish; flesh white, thick, firm, odor and taste not distinctive; lamellae "Shell Pink" to "Pale Grayish Vinaceous" and soon spotted reddish purple, decurrent, close to subdistant (60—70 reach the stipe), narrow; stipe 4—10 cm. long, 1—2 cm. thick at the apex, tapered to a point at the base, solid, dry, silky fibrillose up to the apical evanescent fibrillose ring from the remains of a fibrillose partial veil, silky at the apex, more or less concolorous with the pileus below and often spotted with dark purplish red; spores 5.5—7  $\times$  3.5—4 $\mu$ , ellipsoid, hyaline, smooth; basidia four-spored; gill-trama of divergent hyphae.

Gregarious under spruce, California, and Colorado (the latter by Kauffman) and possibly in Washington. Mr. D. E. Stuntz of Seattle sent us a collection which belongs in either *H. capreolarius* or this species. The fibrillose veil of *H. purpurascens* is not always visible in dried material, and the colors of dried specimens of both are about the same.

Subsec. *Atro-cinerei*

Here we have grouped all the dark gray to pale gray or fuscous to blackish species with dry stipes.

42. *HYGROPHORUS AGATHOSMUS* Fr. Plate 22.

Pileus (3) 4—8 (11) cm. broad, convex to obtuse with an inrolled margin, becoming plane or with the disc slightly depressed in age, sometimes remaining slightly umbonate, glutinous to viscid, glabrous, margin very faintly tomentose, evenly "Light Drab" or a dull ashy gray, scarcely fading, sometimes with watery zones or spots near the margin; flesh soft, whitish or watery gray, taste mild, odor fragrant and very pronounced; lamellae white becoming sordid grayish in age, adnate, becoming adnato-decurrent, close to distant (40—50 reach the stipe), moderately narrow,



Plate 22, *Hygrophorus agathosmus* Fr. xi.



rather thin; stipe 4—8 (10—16) cm. long, 6—14 (18—25) mm. thick, equal or narrowed toward the base, solid, dry or moist but no gelatinous universal veil present, evenly fibrillose pruinose over all at first, glabrescent, whitish at first, pale ashy in age; spores 7—9  $\times$  5—6 $\mu$ , hyaline, ellipsoid, smooth; basidia four-spored; gill-trama of divergent hyphae.

Scattered under spruce and pine, common in California, Oregon and Washington. Kauffman collected it in Colorado and Wyoming. It is particularly abundant in pastures around scattered spruce trees, but has also been found in dense conifer forests. The large specimens collected in southern Oregon with caps 11 cm. broad and stipes 16 cm. long and 2.5 cm. thick were most unusual, but are nothing more than growth forms, and are not taxonomically significant. One must be continually on guard when collecting in this area not to allow oversized specimens to influence his concept of the species in hand.

43. *HYGROPHORUS CAPRINUS* Fr. Plate 23.

Pileus 4—7 cm. broad, convex to turbinate, occasionally either plane or with a slight umbo, surface subviscid when wet, soon dry, evenly "Fuscous" over all, appearing virgate with lighter and darker streaks or patches but glabrous under a lens, margin downy pubescent to pruinose at first, flesh thick, white, fragile, taste mild, odor very slight, reminding one of coal tar; lamellae whitish or faintly tinged cinereous, adnate, becoming short decurrent, close, sometimes subdistant, moderately broad, thin; stipe 3—4 cm. long, 1—2 cm. thick, equal or tapering downward, solid, flesh pale cinereous, dry over all, pallid fuscous or concolorous with the pileus, color ceasing abruptly at the line of gill attachment, appressed silky or faintly pruinose above, nearly glabrous toward the base; spores 7—9  $\times$  4—5 $\mu$ , ellipsoid, hyaline, smooth; basidia four-spored; gill-trama of narrow divergent hyphae.

Gregarious under spruce, Ontario and Washington. Smith, in company with Prof. H. S. Jackson of the University of Toronto, collected this species at Lake Timagami, Ontario in 1936. Specimens from Massachusetts have also been examined. The virgate almost dry pileus and the gills which become grayish in age clearly distinguish it from the closely related but distinct *H. calophyllus* Karst. The latter is glutinous when wet, and distinctly viscid at other times besides being evenly colored, having white to pale pink gills and mild taste. There was a slight difference in the spore size as well, but it does not appear to be significant.

44. *HYGROPHORUS CALOPHYLLUS* Karst. Plate 24.

Pileus 5—11 cm. broad, convex, obtuse or with a low umbo and a decurved margin, nearly flat in age, glutinous to viscid, glabrous beneath the gluten, "Raw Umber," "Dresden Brown" or "Olive-Brown" over all



Plate 23, *Hygrophorus caprinus* Fr. XI.

or slightly paler near the margin; flesh thick, whitish, odor faintly fragrant, taste mild, no color changes noted; lamellae white or evenly flushed with pale pink ("Pale Pinkish Buff") not spotted, subdistant to distant, narrow, decurrent; stipe 6—10 (12) cm. long, 10—15 mm. thick, equal or



Plate 24, *Hygrophorus calophyllus* Karst. x1.

slightly enlarged above, solid, flesh whitish and unchanging, surface dry, glabrous and unpolished or the apex slightly fibrillose pruinose, "Buffy Brown" up to an abruptly paler zone at the line of gill attachment, somewhat uneven below, the basal buried portion gray and watery but not viscid; spores  $5.5-7.5 \times 4-5\mu$ , hyaline, ellipsoid; basidia four-spored; gill-trama of divergent hyphae.



Singly under fir and pine, California, Oregon and Colorado. Kauffman (5) recorded it from Colorado. It has been made a variety of *H. caprinus* by some, but is now generally regarded as distinct. Both this and the preceding are properly classed in the subgenus *Limacium* because of their divergent gill-trama.

45. *HYGROPHORUS FUSCO-ALBUS* var. *occidentalis* Kauff. Agaricaceae of Mich., p. 187. 1918.

"Pileus 2—5 cm. broad, convex-expanded, at length plane or depressed, viscid when moist, livid grayish-brown to brownish-ashy, sometimes blackish on disk, glabrous, even, becoming fragile, margin at first involute and floccose-downy. Flesh white, rather thin, rather soft. Gills adnate to decurrent, subdistant to close, rather narrow, creamy-white, interspaces venose, trama of divergent hyphae. Stem slender, rarely stout, 3—7 cm. long, 4—6 mm. thick (rarely 10—12 mm.), equal or tapering downward, dry, solid, straight, or curved at base, sometimes flexuous, rather fragile, apex floccose-scabrous, floccose-pruinose elsewhere, glabrescent, white or pallid. Spores elliptical, smooth, 6—8 × 3.5—4.5 micr. white. Basidia slender, 36—38 × 6—7 micr. 4-spored. Odor and taste mild.

"Gregarious or subcaespitose. On the ground in oak woods. Ann Arbor, Detroit. October. Infrequent."

Kauffman had commented as follows upon this fungus in his unpublished notes: "Distinguished from its relatives by a rather slender dry stem which is distinctly white floccose-dotted, and by the creamy gills and the spores. *H. livido-albus* Fr., it is agreed, has distinctly larger spores. . . . The European species (*H. fusco-albus*) is generally said to grow in conifer forests. From *H. fusco-albus* (sensu Ricken) it differs by the absence of the glutinous sheath on the stem.

"The change in color of the pileus during development and on drying out is rather marked. The pileus, in a very fresh or young condition (wet weather) is 'Brownish Olive' (R) or darker on the disc and 'Olive-Ochre' toward the margin. Under these conditions it is glutinous, shining and even. It dries out rapidly on exposure to a dryer atmosphere and the surface then becomes much paler, with shades of gray and with a dull lustre. The partial veil is very evanescent."

#### APPENDIX

*HYGROPHORUS AMYGDALINUS* Pk. Bull. Torrey Bot. Club 25:322. 1898.

"Pileus thin, convex or nearly plane, glabrous, slightly viscid when young, grayish brown, the margin incurved, naked, odor amygdaline; lamellae thin, subdistant, adnate or decurrent, white; stem rather long, slender, solid, equal to rarely narrowed at the base, minutely scurfy or squamulose, slightly viscid, grayish brown, paler at the base; spores ob-

long-elliptical, 10—12.5 $\mu$  long, 5—6.5 $\mu$  broad. Pileus 2.5—3.5 cm. broad; stem 5—15 cm. long, 4—6 mm. thick.

"Gregarious in pine woods, Tacoma Park, D. C. November. Mrs. Williams.

"The species is related to *H. cerasinus*, from which it may be separated by its thinner grayish-brown pileus, its white lamellae with no pinkish hue, its grayish-brown stem and its larger spores."

Murrill (12) placed it in synonymy with *H. hypothejus*, very likely because of the stature and the greenish gray color of the dried pileus. Sections of the type show that it is a *Limacium* and that its spores measure 9—12  $\times$  5—6.5 $\mu$ . It needs further study.

HYGROPHORUS CAERULESCENS Berk. & Curt. Ann. Mag. Nat. Hist. III. 4:292. 1859.

"Pileus 2 inches across, nearly flat, thick and obtuse in the center, viscid when moist, shining with a satiny lustre when dry, of a delicate blue-drab color; stem 2½ inches high, ⅓ inch thick, attenuated downwards, smooth, pale blue, at first firm then soft and hollow, gills few, rather thick and fleshy, decurrent, darker than the pileus; interstices corrugated. A very beautiful species. Curt. no. 5434. In woods amongst dead leaves and sticks, which adhere to it. New England, C. J. Sprague."

Murrill (12) says of it "Like all Sprague's collections at Kew, this is accompanied by excellent notes and a beautiful sketch, which is very similar to *Camarophyllus fulvosus* in shape." As far as we are able to determine there is no evidence indicating that this species is a *Limacium*.

HYGROPHORUS ELEGANTULUS Pk. Bull. Torrey Bot. Club 22:200. 1895.

"Pileus convex or nearly plane, glabrous, viscid, grayish-yellow or slightly tawny, flesh white; lamellae distant, slightly decurrent, white; stem equal, solid, slightly floccose-squamulose at the top, elsewhere glabrous, glutinous, white or whitish, sometimes abruptly pointed at the base; spores elliptical, .0004 in. long, .0002—.00024 broad. Pileus 1—2 in. broad; stem 2—3 in. long, 3 to 4 lines thick.

"Woods. Maryland. November, T. Taylor. The species belongs to the tribe *Limacium*, and is related to *H. discoideus* Fr. from which it may be separated by its solid stem and larger spores."

The type reminds one somewhat of a slender *H. paludosus*, but the description of the fresh specimens does not suggest such a relationship. It needs further study.

HYGROPHORUS MONTANUS Murrill, Mycologia 3:199. 1911.

"Pileus plane or convex, smooth, depressed, gregarious, 2.5 cm. broad; surface smooth, viscid, stramineous to isabelline, with a testaceous tint, margin incurved, white, entire; lamellae adnexed, rather broad, yellowish-white, discolored in blotches on drying, pruinose on the edge; spores pip-

shaped, smooth, faintly yellowish,  $8-10 \times 4-5\mu$ ; stipe shining, watery-white, smooth, cylindric, equal, fleshy-fibrous, 4 cm. long, 5 mm. thick; veil very slight, not forming an annulus.

"Type collection on the ground in a trail at New Haven Gap, Jamaica, 5,600 ft. elevation, January 4, 1909, W. A. & Edna L. Murrill 769."

HYGROPHORUS MORRISII Pk. Bull. Torrey Bot. Club. 26:64. 1899.

"Pileus thin, convex, obtuse or umbonate, covered by a viscid separable pellicle, even, grayish brown or blackish brown, flesh whitish; lamellae subdistant, adnate or slightly decurrent, often slightly eroded or uneven on the edge, white; stem rather slender equal or slightly tapering downward, solid, straight or flexuous, flocculently furfuraceous, pallid or brownish; spores elliptic or oblong,  $10-12\mu$  long,  $5\mu$  broad. Pileus 1.5—2.5 cm. broad. Stem 4—6 cm. long, 3—5 mm. thick. Under pine trees, Waltham, Mass. November. G. E. Morris.

"This species is closely related to *H. pustulatus* Fr., but differs from it in the entire absence of pustules or papillae from the uniformly colored pileus and in having a solid stem which, though somewhat scurfy, is not rough or scabrous with black points. The presence of concolorous papillae on the pileus and of black points on the stem of *H. pustulatus* is given by Fries special emphasis in his description of this species. In *Icones* he describes the lamellae as very entire (*integerrimae*) which character is not applicable to our plant. These differences seem to me too important to be disregarded and I take pleasure in dedicating this interesting American species to Mr. George E. Morris, who sent me numerous specimens of it in fine condition."

Murrill (12) reduced it to synonymy with *H. hypothejus*, but in our estimation it is closer to *H. tephroleucus*. We hesitate to refer it to that species however because of a few specimens which the senior author collected under pine at Wilderness State Park in Emmet Co., Mich., in 1934. These were slightly larger than specimens of *H. tephroleucus* and the scurfy covering of the stipe was not cinerascens. These may belong to Peck's species or to *H. fusco-albus*, and the possibility of *H. Morrisii* and *H. fusco-albus* being the same is by no means excluded.

HYGROPHORUS SEROTINUS Pk. Bull. N. Y. State Mus. 116:32. 1907.

"Pileus fleshy but thin, convex or nearly plane, often with the thin margin curved upward, glabrous or with a few obscure innate fibrils, reddish in the center, whitish on the margin, flesh white, taste mild; lamellae thin, subdistant, adnate or decurrent, white, the interspaces slightly venose; stem equal, stuffed or hollow, glabrous, whitish; spores white, elliptic, .0003 of an inch long, .0002 broad.

"Pileus 8—15 lines broad; stem about 1 inch long, 1.5—2.5 lines thick. Gregarious or caespitose in woods of oak and pine. Shore of Hammond pond

near Boston, Mass. November. Mrs. E. B. Blackford."

Sections of some of Mrs. Blackford's specimens were made. The gill-trama revives well and is very distinctly of the interwoven type. The basidia measure  $18-20 \times 4-5\mu$ , and are four-spored. They do not remind one of *Hygrophorus* basidia at all. The spores measure  $5-6 \times 3\mu$ . This species is definitely not a *Limacium* and in our estimation should be excluded from the genus *Hygrophorus*.

HYGROPHORUS SUBLURIDUS Murrill, Bull. Torrey Bot. Club 66:159. 1939.

"Pileus convex to expanded, broadly umbonate, solitary, about 3 cm. broad; surface slimy-viscid, fuscous, glabrous, delicately reticulate in part, margin even, entire; context rather thin, white, unchanging, odorless; lamellae adnexed, rounded behind, ventricose, crowded, inserted, entire, pallid to fuscous; spores globose or subglobose, smooth, hyaline  $3-4\mu$ ; cystidia none; stipe equal, smooth, glabrous, subconcolorous, about  $6 \times 0.4$  cm."

The type was collected near Gainesville, Fla. The description does not state whether the stipe is viscid or whether the gill-trama is composed of divergent hyphae. The description of the gills and the small globose spores are very suggestive of species of *Camarophyllus*. For the present at least, the subgeneric position of this species remains doubtful.

HYGROPHORUS SUBPRATENSIS Murrill, Mycologia 3:198. 1911.

"Pileus convex, obtuse, gregarious, 3—4 cm. broad; surface pale fuscous when young, becoming pallid or whitish with darker disk, slimy-viscid, not striate, pellicle separable; context white, unchanging, odor and taste mild; lamellae deeply sinuate, broad, crowded, white; spores globose or subglobose, smooth, hyaline,  $5\mu$ ; stipe cylindric, equal, slimy-viscid, white, solid but spongy, 3—4 cm. long, 3—4 mm. thick; veil slimy-viscid, scarcely leaving an annulus.

"Type collected on lawns at Santiago de las Vegas, Cuba, June 1, 1905, F. S. Earle 373. Also collected on banana trash in the same locality, June 16, 1904. F. S. Earle 68."

HYGROPHORUS SUBVIOLACEUS Pk. Ann. Rep. N. Y. State Mus. 53:842. 1900.

"Pileus firm, hemispheric becoming convex, glabrous, viscid, hygrophanous, violaceous when moist, paler or grayish when dry, flesh white; lamellae arcuate, distant, decurrent, pale violaceous; stem equal or tapering downward, solid, glabrous, white; spores subglobose or broadly elliptic, .00024 to .0003 of an inch long, .0002 to .00024 broad. Pileus 1—1.5 inch broad; stem 1 to 1.5 of an inch long, 2—4 lines thick. Damp mucky ground in swamps. Meadowdale, October. The species belongs to the Tribe *Lim-*



*acium*. In the dried specimens the pileus is nearly black and the lamellae are smoky brown."

We did not locate the type specimens. Peck's description and illustration are very suggestive of the subgenus *Camarophyllus*.

HYGROPHORUS VIRGATULUS Pk. Ann. Rep. N. Y. State Mus. 26:64. 1874.

"Pileus convex or expanded, viscid when moist, minutely virgate with innate blackish fibrils, whitish with a brownish disk; lamellae distant, arcuate-decurrent, white; stem solid, viscid, equal or tapering downwards, with a few small white floccose scales at the top. Plant subcespitose 2—4' high, pileus 1—2' broad, stem 2—3' thick. Ground in open woods. North Greenbush, October, The lamellae change color in drying as in *H. eburneus*."

The gill-trama of the type is divergent and the spores measure 7—9  $\times$  4—5 $\mu$ , the basidia 28—34  $\times$  5—6 $\mu$ . The dried specimens from North Greenbush are pale and sordid yellowish brown. They do not remind one of *H. occidentalis*, *H. pustulatus* or any other grayish brown species which we have studied.

#### LITERATURE CITED

1. BATAILLE, FRÉDÉRIC. Flore Monographique des Hygrophores. 1910.
2. BRESADOLA, J. Iconographia Mycologica Fas. VII. 1928.
3. BRITZELMAYER, M. Revision der Diagnosen zu den von M. Britzelmayer aufgestellten Hymenomyceten-Arten. IV. Folge. Botanisches Centralblatt 80:116-126. 1899.
4. KAUFFMAN, C. H. The Agaricaceae of Michigan. Lansing, Mich. 1918.
5. ——— The mycological flora of the higher Rockies of Colorado. Papers Mich. Acad. Sci. Arts and Letters 1:101-150. 1922.
6. KONRAD, P. Notes critiques sur quelques champignons du Jura. Quatrième série. Bull. Soc. Myc. de Fr. 45:35-77. 1929.
7. ——— Notes critiques sur quelques champignons du Jura. Sixième et dernière série. Bull. Soc. Myc. de Fr. 52:35-53. 1936.
8. KÜHNER, R. Contribution à l'étude des Hyménomycètes et spécialement des Agaricacés. Le Botanist 17:1-225. 1926.
9. LANGE, JAKOB E. Studies in the agarics of Denmark. V. Dansk Botanisk Arkiv 4(4):1-56. 1923.
10. MORGAN, A. P. The mycologic flora of the Miami Valley, O. Jour. Cincinnati Soc. Nat. Hist. 6:173-199. 1883.
11. MURRILL, W. A. The Agaricaceae of the Pacific coast. Mycologia 4:205-217. 1912.
12. ——— Hygrophorus. North American Flora 9<sup>6</sup>:390-396. 1916.
13. ——— New Florida agarics. Mycologia 30:359-371. 1938.
14. NÜESCH, EMIL. Die Weissporigen Hygrophoreen. Heilbronn a. Neckar. 1922.
15. PECK, C. H. New York Species of *Hygrophorus*. New York State Mus. Bull. 116:45-67. 1907.
16. REA, CARLETON. British Basidiomycetae. Cambridge. 1922.
17. RICKEN, A. Die Blätterpilze. Leipzig. 1915.
18. SINGER, ROLF. Das System der Agaricales. Annales Mycologici 34:286-378. 1936.
19. SMITH, ALEXANDER H. Unusual Agarics from Michigan. Papers Mich. Acad. Sci. Arts and Letters 19:205-216. 1934.
20. ——— Unusual agarics from Michigan IV. Papers Mich. Acad. Sci. Arts and Letters. 22:215-223. 1937.
21. ——— Studies in the genus Cortinarius I. Contributions from the University of Michigan Herbarium. 1939. (In press.)
22. ZELLER, S. M. Contributions to our knowledge of Oregon fungi.—I. Mycologia 14:173-199. 1922.

# The Evolution of Habit in *Tempskya*\*

CHARLES B. READ

(*U. S. Geological Survey, Washington, D. C.*)

In connection with morphological studies of plants, both living and fossil, growth form is very commonly taken into consideration, but it is usually looked upon as a static feature. Attention is seldom given to its origin and development (1, 2) processes that may be best designated the evolution of habit.

The present contribution deals with this problem of habit or the evolution of growth-form in a remarkable genus of Cretaceous ferns, *Tempskya*. These ferns are characterized by a false stem, which is a composite structure with the mechanical functions of a true stem. A consideration of the morphological features of these plants almost immediately raises the question of habit development.

## MORPHOLOGY OF TEMPSKYA

The genus *Tempskya* (4, 6) is an extinct group of leptosporangiate ferns characteristic of the younger Mesozoic. In western North America these plants are found well preserved in strata of early Upper Cretaceous age (Colorado group). Similar but less perfectly preserved remains of species of this genus are present in various Cretaceous strata of eastern North America and Europe.

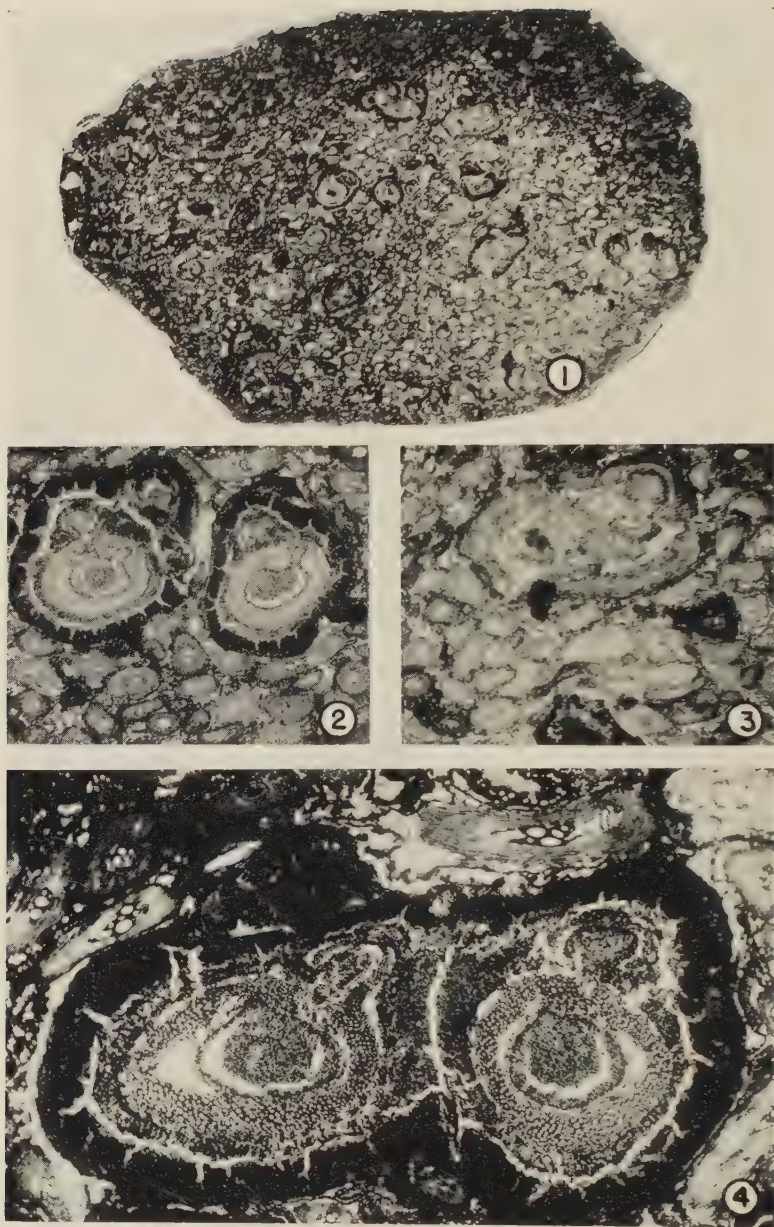
The remains of these plants generally consist of silicified masses of stems and roots, the organs of these two categories roughly paralleling each other. In consequence a dense ropelike mass is developed which has been termed a false stem (5).

A transverse section of one of these false stems is shown in Plate 1, Fig. 1. The groundmass of small organs is root material. The larger structures are remains of stems. These individual stems, it will be noted, are solenostelic and markedly dorsiventral with two rows of alternate leaves borne on the morphologically upper surfaces. On the lower surfaces adventitious root insertions are common.

Details of typical stems and roots are illustrated in Plate 1, Figs. 2, 3, and 4. The dorsiventrality of the stems is quite evident, and it will be observed that the roots are diarch. A feature of some interest is the fact that the stems are quite commonly broken down and penetrated by the investing root system (Pl. 1, Fig. 3). The leaf traces are horseshoe-shaped strands and are developed after the manner typical of such ferns. Several stages in leaf trace emission are shown in Plate 1, Figs. 2, 3, and 4. The xylem of the stem is exarch, and phloem is present both outside and inside the xylem ring.

Returning to the morphology of the false stem, it is interesting to contrast the structure shown in Plate 1, Fig. 1, with that illustrated diagram-

\* Published with the permission of the Director, United States Geological Survey.



## PLATE I

Fig. 1. A photograph of a transverse section of *Tempskya knowltoni* Seward showing the relationships of organs and the dorsiventrality of the false stem (x 1.75).

Figs. 2, 3. Transverse sections of dichotomizing stems of *Tempskya knowltoni* Seward showing general morphology. Note that the stems in Fig. 3 have been penetrated by the investing roots (x 6).

Fig. 4. A transverse section of a stem of *Tempskya knowltoni* Seward showing some of the details of structure (x 20).



matically in text figure 1. It is fairly certain that the structure shown in Plate 1, Fig. 1, is complete insofar as the stems are concerned, since the original fossil was somewhat obconical in shape and contained but a single stem at its base. The numerous stems seen in higher sections are obviously derived by repeated dichotomy of the parent organ. The leaf traces in the numerous stems in this specimen, which is the type of *Tempskya knowltoni*, are all directed towards one side of the false stem. In consequence this latter structure is likewise dorsiventral.

With respect to the orientation of the stems the situation is quite reversed in the form illustrated in text figure 1. Here the leaf traces of the dorsiventral stems are in every case directed towards the nearest point on the periphery of the false stem, so that the symmetry of the composite structure is radial.



Fig. 1. Diagram of a transverse section of the false stem of *Tempskya grandis* Read and Brown showing the radial symmetry  $\times \frac{1}{2}$ .

To recapitulate briefly, the extinct fern genus *Tempskya* is characterized by a dichotomously branching amphiphloic, solenostelic stem system. The individual stems are dorsiventral, that is, the leaves are borne in two ranks on the morphologically upper surfaces. On the lower surfaces of the stems there are produced numerous adventitious roots. These tend to parallel the stems. In consequence a dense, ropelike mass is formed which is a composite "organ" consisting of a branching stem system bound together by a felt of adventitious roots. This has been termed a false stem. In the American material, there are forms characterized by dorsiventrality (that is, with the stems all oriented so that the leaves are directed toward one surface of the false stem), and other types characterized by radial symmetry of the false stems.

The problem of the affinities of this genus has not yet been fully solved. It appears to be related to the Schizaeaceae on the one hand and the



Gleicheniaceae and Loxsomaceae on the other. A full discussion of this matter is published elsewhere (6).

#### PUBLISHED VIEWS CONCERNING THE HABIT OF TEMPSKYA

With these morphological details in mind, attention may be directed now towards interpretations in terms of habit. Several opinions have already been expressed in the literature, and these must first be considered. The writer prefers to omit from this discussion the early views of Corda, Velenovsky, Unger, Schenk, Feistmantel, and Seward (9), since those investigators had an improper conception of the morphology of the plant.

Kidston and Gwynne-Vaughan (5) were the first to realize the true nature of *Tempskya* and as a result of their work on *T. rossica* suggested that the plant had an upright habit not unlike that of a low tree fern with a crown of leaves. A few years later Stopes (11) discussed the genus and published a restoration of *T. rossica* according to the ideas of Kidston and Gwynne-Vaughan.

In 1924 Seward published the results of his study of *Tempskya knowltoni* from the Cretaceous of Montana. In discussing habit he wrote:

An examination of the American material leads me to express an opinion different from that of Kidston and Gwynne-Vaughan. . . . The general, though not invariable, tendency of the roots to follow a vertical course does not . . . justify the assumption of an erect position. The mass of compact roots seen in the fossil was probably covered during life by a much looser felt of roots which grew into the soil. . . . Moreover, hydrotropism as well as geotropism must be taken into account. . . .

I believe that the available evidence supports the conclusion that the false stem of *Tempskya*, or at least of *T. knowltoni*, may best be compared with the obliquely ascending, and for the most part subterranean, stem of such a Fern as *Dryopteris Filix mas*. (10).

And, in final analysis, "It may be that *Tempskya* in its earlier stages of growth was at least in part below the surface of the soil and resembled *Dryopteris Filix mas*, in the orientation of the fronds. The Montana specimen probably represents such a comparatively juvenile stage as I have described. At a later stage the false stem may have assumed a more or less vertical position, and when this happened the stems would no longer exhibit any regularity in the orientation of the fronds. (10)

#### PRIMARY ASSUMPTIONS

Owing to the nature of the material upon which this paper is based the statements set forth below can have only theoretical significance. Consequently, it is desirable to outline certain primary assumptions which are necessary to the discussion.

1. The false stem is a composite "organ" analogous to a stem from the mechanical and to some extent from the physiological point of view.

2. The form, both external and internal, of a stem or false stem, is to some extent influenced by the habit of the plant. If upright there is a tendency towards radial development, and if horizontal the shoot tends towards dorsiventrality. A perfect morphological reflection of habit is by no means prevalent among ferns, however, and this lack of correlation is certainly related to a structural lag. In other words, external morphology is more plastic than internal form.

3. The false stem is much more plastic than the true stem. Accepting the false stem as a structure analogous with a true stem in the respects set down above, it is evident that the internal structure can change much more rapidly than in a true stem. The individual units of the false stem are distinct organs which are linked mechanically. As a result, they may vary their orientation and position rather quickly in response to external influences. The possibility of structural incompatibility of the false stem with the growth form is thus greatly minimized. In fact, a close correlation may reasonably be predicted.

#### PROBABLE GROWTH FORMS

An examination of the evidence from which the habit of *Tempskya* can be inferred is now in order. Considering first the ideas recently expressed by Seward, the observed facts which suggest the horizontal or obliquely ascending and possibly subterranean habit are:

1. The marked dorsiventrality exhibited by some forms, notably *T. knowltoni* Seward, as well as other types in the writer's collections. This is perhaps the most important bit of evidence supporting Seward's contention, and if the type specimen of *T. knowltoni* alone is considered it is fairly conclusive. Certainly dorsiventrality of the false stem does suggest a freely branched *Dryopteris* rhizome in which a marked tendency toward the development of adventitious roots has manifested itself.

2. The dorsiventrality of the true stems within the false stem is likewise a clear indication of the horizontal habit during some stage in the development of the group.

3. The alleged occurrence of gymnospermous roots in the root felt is held by Seward (9) as evidence of the subterranean position. (However, the writer has examined these structures and is by no means sure that they are roots. The sections are all rather oblique and indecisive. And even granting that they are roots, they may be remains of a conifer which grew on the plant after death.)

4. While the tendency toward parallelism of root and stem is marked in the preserved fossil there may have been a loose outer felt of roots which departed from this parallelism but which is not preserved. Even though the roots and stems are parallel this may be due, as Seward says, to hydrotropism. All of this is purely speculative, however.

5. Even in the radial types there is a possibility of horizontal habit on the basis of an analogy with any of the many radially symmetrical stelar types which are horizontal (*Polystichum*, *Asplenium*, *Osmunda claytoniana*, etc.). However, under such conditions, it is difficult to understand the stages in habit evolution which would result in a radially symmetrical *false stem* when the dorsiventral one could have been as readily achieved. The latter would also be much more likely owing to the already dorsiventral nature of the stem.

6. The fact that the older portions of the stems are broken down (and often are penetrated by roots) is a characteristic observed in subterranean stems of ferns and is certainly in accord with the idea of an essentially horizontal false stem in *Tempskya*.

7. As Seward says, it may not be easy to explain the transport of water by roots to the upper portions of stems in a columnar false stem in which the lower portion consists in part of decayed stems which were certainly physiologically functionless. But if the false stem were prone, all roots would be within easy reach of the water-bearing substratum.

The possibility of an erect axis in the case of those *Tempskya*s characterized by the radial false stem shown in text figure 1 may now be considered. In support of this, the following statements are submitted:

1. The radial symmetry of the false trunk. In such an obviously plastic structure it is difficult to harmonize any habit other than an erect one with the structure. As has already been stated, there might be pointed out the possibility of an analogy with certain radial yet horizontal stems which are found in the Filicales. Such a comparison is not very conclusive, however, if the assumptions suggested by the writer regarding plasticity in true and false stems be admitted.

2. The parallelism of root and stem. This is quite striking and, while by no means an absolute criterion of the upright condition, is suggestive. And it is note worthy that, while numerous specimens have been examined, in no case is there any evidence of a loose outer root zone which suggests divergence of these organs.

3. The "raimentum-like" nature of the root felt. Many tree ferns produce a dense felt of adventitious roots. The great mass of roots in *Tempskya* is rather suggestive of this "raimental" zone.

4. The size of the false stem. Some of these radial false stems are 6 or 8 inches in diameter. It is most likely that a structure of that size stood upright. If it were horizontal there would be no very apparent reason for the concentration of roots and stems into such a large compact mass, which might be physiologically unsound.

It is apparent that if these radially symmetrical false stems were upright they could not have reached any great height unsupported. Rather one would picture them as short tree ferns. The roots, which are characterized by abundant sclerenchyma, would, of course, serve as props but could not be expected to be very efficient in supporting a long trunk. Further, in no case in the specimens handled has there been observed a breaking down of stems in this radial form. Despite some evidence which may be interpreted to the contrary, the writer believes that these false stems with radial symmetry must have stood upright. This is, of course, the point of view taken by Gwynne-Vaughan and Kidston (5) and apparently even by Seward (10).



As an alternative in the case of the dorsiventral false stemmed types it is suggested that these were climbing plants either on cliffs or, liana-like, on arborescent plants. The following facts make this suggestion tenable:

1. The dorsiventrality of the false stem is evidence of one surface being free from leaves, a feature as characteristic of climbing plants as of creeping types.

2. The parallelism of roots and stems is a feature to be expected only in the case of an approximately upright position of the stems. If the opinion that the radially symmetrical false stems were upright is accepted, then their identity in structure with the dorsiventral types in all features except

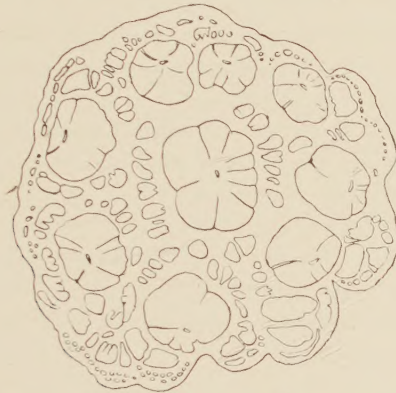


Fig. 2. Diagram of a transverse section of the stem of *Serjania multiflora* Camb., a liana (after Schenck).

symmetry must be taken at once as evidence of the upright habit of the latter.

3. The ability of the adventitious roots to function as holdfasts is a common function of roots in ferns (*Trichomanes scandens*, *T. venosum*, *Oleandra*, *Stenochlena aculeata*, *S. scandens*, etc.). Little evidence is seen in the specimens of *Tempskya* in favor of this. It is doubtful if holdfast roots would be preserved.

4. The mechanical perfection of the false stem as a climbing device. The false stem of *Tempskya* is a striking example of a structure combining the maximum of strength with the minimum of rigidity. The great quantity of sclerenchyma incorporated in the construction of both roots and stems plus their interwoven but chiefly parallel orientation suggests a rope-like organization. Analogies are to be seen in many climbing types, one of which is figured in text figure 2. In this plant, *Serjania multiflora* Camb., the anomalous ropy structure has been developed through the distintegration of the woody cylinder of a single stem. The result from a mechanical point of view is quite similar to that manifested by the false stem of *Tempskya knowltoni*.



5. The possibility that the leaves may have had a prehensile function, as in *Lygodium*. No evidence is at hand, however, for or against such a possibility, the leaves, except for their bases, being unknown.

It has already been pointed out that in the older portions of the false stems the true stems are broken down and penetrated by roots and presumably become physiologically functionless (Pl. 1, Figs. 2-3). It, therefore, follows that these plants, if climbers, become in the later stages of individual development saprophytic on the older portions of their own false stems, and may in time have actually become epiphytes through the parting of the decayed portion of the trunk. Again, the remaining portion of the false stem would have functioned as a spongelike mass capable of water storage. In short, the writer's concept of the growth form of the dorsiventral false stemmed species of *Tempskya* is an ascending, climbing type of fern with numerous liana adaptations. It is of course obvious that the very basal portions of the stem were horizontal or oblique. However it is doubtful if these subterranean portions developed the dense mass of parallel roots characteristic of the false stem. Rather they must have been markedly divergent.

According to Schimper there are certain lianas at the present day "that germinate in the soil, but their stems gradually die from below upward, so that in their later stages they subsist just like hemi-epiphytes. They have been termed pseudo-epiphytes" (8). Thus a situation exactly comparable to that suggested here for *Tempskya* is found in the modern flora.

The false-stemmed condition is not entirely peculiar to *Tempskya*. Sahní (7) has summarized the facts concerning other forms that show it. Among living ferns, *Todea barabara* Moore and *Hemitelia crenulata* Mettenius furnish examples. *Clepsydropsis australis* Osborne and *Clepsydropsis kirgisica* Stenzel are instances among Paleozoic types. It is apparent, however, that these are different stocks and furthermore show architecture in false-stem construction rather different from that of *Tempskya*. In consequence, comparison cannot be carried far.

In summation, the genus *Tempskya* presents a degree of variability in the morphology of its false stem that denotes considerable diversity of habit. The features presented by those false trunks with radial symmetry point to the upright habit of a tree fern. On the other hand, the writer believes that those with dorsiventral asymmetry may have been climbing types, and it is possible that they may actually have developed into pseudo-epiphytes.

#### ORIGIN AND EVOLUTION OF THE FALSE STEM OF TEMPSKYA

There remains for consideration only the origin of the false stem, which is unique and which alone is nearly sufficient to characterize the genus. According to Bower (3), "it is possible to contemplate a primitive Fern-

sporophyte as a simple, upright, radial . . . shoot." This concept of a radial, upright fern prototype seems to be generally accepted by students of morphology, and it may be assumed as a starting point. Somewhat parenthetically it may be pointed out that the Paleozoic ferns, so far as the present status of knowledge concerning them goes, are predominantly radial. The development of the dorsiventral rhizome in the ferns may perhaps be interpreted as an adaption to the rigorous environments which marked the close of the Paleozoic.

The dorsiventral progenitor of *Tempskya* must have been a markedly dichotomous type which produced numerous adventitious roots. The divergence of the dichotomies was slight, the branches were nearly parallel.

This lineage of ferns, the author believes, must gradually have developed the climbing or scandent habit with increased development of adventitious roots, these tending to parallel the stems for the most part, except in the case of an outer loose zone which served as hold-fasts. Thus the false stem might have been gradually built up as a nearly perfect adaptation to the climbing habit. The weight of the ropy mass would be overcome by the loss of function of the lower portions of the false stem, the result being self-saprophytism, and finally the development, as an old-age characteristic, of the epiphytic habit. It is obvious that such types, with the very flexible morphology characteristic of the false stem, should be dorsiventral.

From these it is but a slight step to the assumption of radial symmetry. The possibilities for such a culmination of form are too many to enumerate, it may have been accidental, or it may have resulted from an increase in rigidity of the false stem. The stems in the radial types are larger than those in the dorsiventral types and suggest this. At any rate, the most reasonable interpretation is that radially symmetrical types (text fig. 1) mark the climax of stem specialization of this group of ferns.

Thus *Tempskya* presents an interesting study, if the interpretations set down are correct, of the reversion of an advanced (dorsiventral) type to the primitive habit. This reversion is characterized, however, not by a return to the original morphology but by the development of a new structure, the false stem, which simulates the old radial shoot. At the same time, from the anatomical point of view the stems and roots retain their high degree of specialization.

#### SUMMARY

1. The genus *Tempskya* Corda, of Upper Cretaceous age in western America, is characterized by a markedly dichotomous solenostelic stem system sheathed in a felt of its own adventitious roots. A composite stem-like structure is thus formed which has been termed a false stem.

2. As primary bases for the discussion, it is assumed that the false



stem is a composite "organ" analogous to a true stem in certain respects; that form is influenced by habit, and that lack of perfect correlation is indicative of a structural lag; and that the false stem is much more plastic than the true stem and, in consequence, a close correlation of habit and internal structure is to be expected.

3. Arguments favoring a subterranean and obliquely ascending habit for these false stemmed types are presented. Likewise, arguments suggesting an erect treefern-like habit for the radially symmetrical false stems, and a climbing habit for the dorsiventral ones are given. It is believed that the available evidence favors the erect and the liana-like habits.

4. Assuming a radial Urform, for which there is ample justification both in theoretical morphology and in the Paleozoic record, the dorsiventral morphology of fern stems may be regarded as developed towards the close of the Paleozoic as an adaptation to rigorous climates which are known to have produced striking changes in the organic landscape.

5. From one of these early dorsiventral types with a dichotomous stem system, *Tempskya* may have been derived through the development of the scandent and tree-climbing habit, aided by the production of a mass of adventitious roots. Thus the false stem could be developed.

6. It follows that the more primitive habit in *Tempskya* is logically the climbing one reflected by the dorsiventral false stem. Old age of individuals may have been characterized by self-saprophytism and finally epiphytism.

7. The radial forms, it is believed, were developed from these dorsiventral climbing types as a result of the assumption of the free, upright habit. This may have been accidental or the result of a progressive increase in rigidity of the false stem due to increase in true stem size.

#### LITERATURE CITED

1. BEWS, J. W. Plant forms and their evolution in South Africa. London, 1925.
2. ———. Ecological evolution of the angiosperms. New Phytol. Repr. 16, 1927. See also bibliographies for other papers.
3. BOWER, F. O. The ferns (Filicales). 1:337. Cambridge Univ. Press, 1923.
4. CORDA, A. J. Flora Protogaea. Beiträge zur Flora der Vorwelt, p. 81, 1845.
5. KIDSTON, ROBERT AND D. T. GWYNNE-VAUGHAN. On a new species of *Tempskya* from Russia. Verh. Russ. K. min. Gesell. 48:1-20, pls. 1-3, 1911.
6. READ, CHARLES B. AND ROLAND W. BROWN. American Cretaceous ferns of the genus *Tempskya*. U. S. Geol. Survey Prof. Paper 186-F:105-131, pls. 27-43., 1937.
7. SAHNI, BERBAL. On *Clepsydropsis australis*, a zygopterid tree-fern with a *Tempskya*-like false stem, from the Carboniferous rocks of Australia. Philos. Trans. Royal Soc. London, ser. B, 217:1-37 (see pp. 27-29, especially), pls. 1-6, 1928.
8. SCHIMPER, A. F. W. Plant geography upon a physiological basis. English translation, p. 321, Oxford, 1903.
9. SEWARD, A. C. Catalogue of the Mesozoic plants in the Department of Geology. The Wealden flora. Pt. 1:148-159, 1894.
10. ———. On a new species of *Tempskya* from Montana: *Tempskya knowltoni*, n. sp. Ann. Bot. 38(151):485-507, text figs. 1-3, pls. 16, 17, 1924.
11. STOPES, M. C. The Cretaceous flora. Part 2. Lower Greensand (Aptian) plants of Britain. Catalogue of Mesozoic plants in the British Museum (Natural History), pp. 9-21, text figs. 2-5, 1915.